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AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PAPER-READING SESSION, FORTY-EIGHTH ANNUAL MEETING

St. Louis, Mo., December 1935

STABILIZING ENTOMOLOGY

LEE A. STRONG, *President, American Association of Economic Entomologists*

Since the second annual meeting of the American Association of Economic Entomologists, in November 1890, its presidents have on retiring from the office delivered addresses successfully calculated to provide food for thought along some particular and pertinent line for those engaged in entomological work, whether members of the Association or not. Some have pointed out the accomplishments of entomologists, some the needs of entomologists and the needs of entomology; some have discussed specific problems facing entomology and entomologists in the line of research; the peculiarities and personalities of workers in entomology have not been neglected; and some have indulged in speculation and prophesies as to the future. Throughout the presidential addresses delivered to the Association almost invariably there has run, probably without definition but none the less clear, one thought—in some cases a hope, in others a belief, in still others the admonition that for the welfare of humanity entomology must be stabilized.

The thought occurs in the statement made by the commissioner of agriculture upon the organization of the Department of Agriculture, following the appointment of Mr. Glover as entomologist, when he said in his annual report for 1863, "Entomology being one of the subjects mentioned in the act establishing this department and the destruction to fruits and other crops by insects having now become so serious, I determined to make it an important branch of the department and have employed a gentleman well known throughout the country as a skillful, practical entomologist who has been paying special attention to the best modes of extirpating insects injurious to vegetation." The act of Congress of May 15, 1862, referred to above, establishing a Department of Agriculture, provided that "The commissioner of agriculture shall . . . as Congress may from time to time provide, employ other persons for such time as their services may be needed, including chemists, botanists, entomologists, and other persons skilled in the natural sciences pertaining to agriculture."

C. V. Riley said in his presidential address at the second annual meeting of the Association of Economic Entomologists, Nov. 12, 1890, which was the first annual address by a president of the Association: "Applied entomology is often considered a sordid pursuit, but it only becomes so when the object is sordid. When pursued with unselfish enthusiasm born of the love of investigation and the delight in benefiting our fellowmen it is inspiring, and there are few pursuits more deservedly so, considering the vast losses to our farmers from insect injury and the pressing need that the distressed husbandman has for every aid that can

be given him. Our work is elevating in its sympathies for the struggles and suffering of others. Our standard should be high—the pursuit of knowledge for the advancement of agriculture. No official entomologist should lower it by sordid aims."

James Fletcher in his presidential address at the third annual meeting said:

> At the last meeting of the Association, in Champaign, Ill., I had the honor of a conversation with Assistant Secretary, the Hon. Edwin Willits, and he mentioned that he was frequently asked for information as to the advisability of large expenditures for entomological purposes, and that although entomologists frequently spoke of the large losses from insects, we did not provide politicians—and particularly himself, with data by which they could explain and justify these expenditures, which those who understood them knew to be of such enormous importance; and when we wished to point out the great injuries done by insects we had to go back continuously to old published records which we had all been quoting for upwards of 10 or 20 years. Now we find upon investigation that accurate estimates of damage done by insects are exceedingly difficult to arrive at, and the figures are so large that we are rather afraid to quote them ourselves lest we should prevent rather than encourage investigation, and it has been the custom of entomologists to minimize the estimates for fear they should not be believed. Now the necessity has arisen, I think, and I lay it before the association for action, in the direction of gathering together some reliable recent statistics in a short form which may be printed for distribution, and which will cover the more important injuries to date, and the part the work of the entomologist has played in reducing injury or preventing loss, so that we may overcome this difficulty and provide legislators and ourselves with data with which to meet this argument.

At the sixth annual meeting, August 14, 1894, in the annual address of President L. O. Howard, there appears the following:

> These great advances, we must remember, would not have been possible without legislative encouragement. Activity on the part of workers and appreciation on the part of the people and their representatives have gone hand in hand. At the present time the amount of money expended for work in economic entomology is far greater in this country than in any other. Our regular annual expenditure in the support of entomological offices amounts to about $100,000, very nearly all of which is appropriated by the general government, $29,000 going to the Division of Entomology of the Department of Agriculture and about $60,000 to experiment-station entomologists. To this amount must be added the large sums expended annually in publishing our reports and bulletins. The sum total thus reached will probably exceed the amount expended in this

> direction by the entire remainder of the world. Much more is therefore to be expected from American workers than from workers in other countries. The American members of this Association must bear this fact in mind, and must realize that with the present rapid increase in interest among other nations nothing but the most energetic and painstaking work will result in the retention by the United States of her present prominent position. In some respects our results have not been commensurate with our opportunities, but we have certainly justified in vast degree the money expenditure which has enabled us to prosecute our work. Not a year passes in which the sum saved to agriculture and horticulture, as the direct result of our work, does not amount to many times that which the government appropriates, as has been often shown, and notably by our former president, Mr. James Fletcher, in his most able and interesting address at our Washington meeting in 1891. . . . We have then done good work. We have accomplished results which have added greatly to the productive wealth of the world. We have justified our existence as a class. We are now better equipped for the prosecution of our work than ever before, and it may confidently be expected that the results of the closing years of the century will firmly fix the importance of economic entomology in the minds of all thinking men of all countries.

Isaac Newton pointed with some pride in 1863 to the appointment of an entomologist in the Department of Agriculture, a department which Mr. Newton said in his report to Abraham Lincoln "occupies a half dozen rooms in the basement under the patent office, a space too limited and inconvenient for any department of this government."

What progress has been made in stabilizing entomology since Newton appointed his entomologist? Can it be measured by the steady accession of man power since that time? Not entirely so, but consider what has taken place in the United States Department of Agriculture, and that should be a fair measuring stick, because entomology in state institutions and in other lines has, by and large, just about kept pace in the respective organizations with the federal organization.

In 1878 entomology was made a division in the Department of Agriculture and in 1880 there was transferred to the department the entomological Commission which had been serving under the Secretary of the Interior under an act of Congress passed in 1877. Since 1878 when the work was given the status of a federal division, appropriations specifically for entomological work have been made and on July 1, 1904 the Division of Entomology became a bureau with an appropriation of $82,450. Howard indicated that in 1894 the appropriation to the Division of Entomology was $29,000. For the fiscal year 1914 the appropriation bill carried for the Bureau of Entomology $742,210. Meanwhile the plant quarantine act of 1912 had been passed and the enforcement of the entomological features of the quarantines under that act were carried

by the Bureau of Entomology. For the fiscal year1924 the appropriation to the bureau was $1,797,880. Effective July 1, 1928 the research and regulatory work on insects in the department were separated, the Bureau of Entomology retaining the research and the regulatory work going to a newly created agency, the Plant Quarantine and Control Administration. In 1927 Howard retired and was succeeded by Marlatt, who from the creation of the Plant Quarantine and Control Administration in July 1928 acted as chief of that organization as well as chief of the Bureau of Entomology until December 2, 1929, when he gave up the quarantine work and gave his attention to the Bureau of Entomology until his retirement October 1, 1933. During this time of more or less frequent changes in legislative and departmental status and changes in management, the results obtained in entomological work must have proven it never should have been "considered a sordid pursuit" as referred to by Riley in 1890 else it could not have weathered the storms and maintained its identity and stability in federal and state organizations.

It would be difficult to over-emphasize the stabilizing influence of the counsel and the active leadership during this long period in the federal bureau; of the teachings of entomology in the colleges and universities of the country and the work in the state experiment stations. All these contributed to the building up of stability by encouraging by precept and example an abiding respect for the profession. No small credit for stabilizing entomology is due those workers who by painstaking and sound research made it possible and practical to undertake the large-scale control operations which have demonstrated the value of entomological research and the practicability of applying the results to the advantage of our citizenship. It was well for entomology, both research and regulatory, that all these stabilizing influences had been at work because during 1933 when reorganization of government departments was under way, when appropriations were being reduced in state and federal institutions, there was much concern as to what was to happen to entomology. This Association realizing, of course, that while retention of unit identity of entomology in the United States Department of Agriculture could not of itself be responsible for stability of the work, the loss of identity might well interfere seriously with the stability built up over a long period of years in a work of vital importance to the welfare of the country. Therefore, a committee appointed by the Association made dignified and pertinent representations of the needs of entomology under all appropriate circumstances. Finally, upon recommendation of the Secretary of Agriculture, Congress provided for the consolidation of the Bureau of Entomology and the Bureau of Plant Quarantine and transferred to the consolidated bureau the plant disease control work being carried on in the department together with the insecticide and chemical work carried on by the Insecticide and Fungicide Division of the Bureau of Chemistry and Soils. Thus on July 1, 1934, exactly 30 years to a day after the creation of the Bureau of Entomology there was set up by act of Congress, the Bureau of Entomology and Plant Quarantine in the department and there was brought back together again into one bureau the research and regulatory work having to do with entomology. For the

current fiscal year the regular funds appropriated by Congress for the bureau total $7,801,421. Special and emergency funds allotted to the bureau total $16,852,817.

In 1894 Howard announced appropriations of $29,000 to the Division of Entomology. In 1935 to the Bureau of Entomology and Plant Quarantine regular appropriations and emergency allotments approximate $25,000,000. Can progress in stabilizing entomology be measured in terms of appropriations? No, but at least something in the way of measurement may be found in the confidence with which appropriations are made and the confidence with which results are expected and obtained. And the greatest influence in finally stabilizing entomology is results. Results depend upon the sensible and courageous application of painstaking, sound, scientific research. Getting results and applying them effectively demand unprejudiced leadership in our institutions and coordinated carefully planned programs. What have we to point to in the way of results?

To mention only a few—the development of lead arsenate and calcium arsenate as insecticides; the development and application of cyanide fumigation to orchards; outstanding accomplishments in the insecticide field. Great strides have been made in the field of biological control, notable among the accomplishments being the introduction into Cuba from Malaya of parasites of the citrus black fly by American entomologists in cooperation with the government of Cuba; the natural control of citrophilus mealy bug in California by parasites introduced from Australia.

In the eradication of insects the cooperative state-federal program in Florida which apparently resulted in the complete extermination of the Mediterranean fruit fly in continental United States; the eradication of pink boll worm of cotton in Louisiana, Georgia, the Salt river valley of Arizona, and large areas in Texas—all cooperative undertakings; the eradication of date scale in Arizona and California; the eradication of gypsy moth in Ohio, over large areas in New Jersey and in the barrier zone. In cooperative research and control programs—the coordinated program now underway in codling moth control; the cooperative program in the control of grasshoppers and the programs against chinch bugs and screw worms.

Outstanding work has been done in the field of taxonomy and morphology but we need much more of it. The insect pest survey, a cooperative project, has in part met the criticism offered by Fletcher in his 1891 address to the Association.

Professionally entomology is one of the younger sciences, even in the biological field. Its youth is attested by the number of new species being more or less constantly found and described. Much has been done and there is much to do. There is plenty of room for plenty of work. In the efforts to stabilize a profession which means so much to human progress, human welfare, and human comfort, we must not overlook the fact that we must find out *about* insects as well as find out what to *do* about insects. This means much more attention to physiology, to the study of insect diseases, and to the transmission of diseases by insects.

What have we had then as stabilizing influences in entomology? First and perhaps most important, an inspiring belief in the purpose and importance of the work by those working in the profession. In addition, a recognition of the validity of the work by federal and state and local institutions; a confidence in the profession which has influenced appropriating bodies to give increasing financial support to the work; a confidence in each other which has made possible the closest cooperation between all institutions doing entomological work and which in turn has brought about a long list of accomplishments contributing to the welfare and comfort of humanity. These and certain accessorial influences, some possibly as important as the few mentioned, have brought about a most gratifying stability in the profession of entomology, but one thing more is needed.

In species and kinds, insects outnumber most, if not all, groups of living organisms. When we recognize this and the importance of protecting man, his crops and possessions from insects, and adding pride in our accomplishments, we are forced to the conclusion that professionally we have finally grown up. Acknowledgment of the relation of entomology to other sciences and realization that many problems require cooperation only emphasize the need for independence equal to that of other groups and in a degree which we have never asserted. We should continue, as we have done in the past, to cooperate in every way with all branches of science—to work for the betterment of the human race through research, pest control, and quarantine, and we should tell the world about it. And finally, when we meet annually in the most important entomological conferences held anywhere in the world, we should have one independent meeting at a time and place of particular and special advantage to our profession so that our work will be given that consideration and recognition it so richly deserves.

THE CROP PROTECTION INSTITUTE

ITS ORGANIZATION, PLAN OF PROCEDURE AND WORK ACCOMPLISHED

W. C. O'Kane, *Chairman Board of Governors, Crop Protection Institute*

Fifteen years have elapsed since the Crop Protection Institute had its beginnings, at a meeting held in Washington, September 28, 1920. In the course of this period the institute has gradually found its place in its relations to experiment stations and to the industrial world. This paper is a review of the institute's development, its method of prosecuting its work, and its accomplishments up to the beginning of the year 1936.

The situation in 1920.—In 1920 relatively few industrial concerns, engaged in activities related to pest control, possessed extensive research departments in that field of effort. For the most part manufacturers were producing standard materials, such as lead arsenate, lime sulfur, and the like, which had an accepted usage. A few were making specialized products.

Yet the needs were steadily increasing for more efficient and more accurate means of controlling destructive insects and plant diseases. Pests that had made their way here from other countries presented special and often difficult problems. The ordinary materials and measures were not always satisfactory or effective. It was necessary that more adequate control of various pests be achieved, as a means toward more profitable agriculture.

A forward-looking manufacturer, who desired to market materials meeting these needs, had no adequate avenues available for logical procedure. If a manufacturer wished to set about development of a new material he needed expert advice from the point of view of the technical men trained in the biological sciences. There was no orderly way in which he could obtain such counsel.

If he possessed a new material which he believed to be promising, he might send samples to experiment station workers. But they were already flooded with samples, most of which had little merit, and they could not give time to a comprehensive series of experiments with a new material. He might send samples to growers for practical tryout. But the results in this case were all too likely to be misleading, for the reason that most growers could not be expected to plan and carry out an adequate experimental program, nor to interpret results correctly.

If an industrial concern was manufacturing materials which were allied to those known to be useful for control of pests, and which might be so modified as themselves to become useful, there was no way of studying the possibilities, selecting promising substances, testing them, appraising the results, and improving the better materials in a constructive way.

The Crop Protection Institute organized.—It was in the midst of this situation that the Crop Protection Institute was organized. It seemed logical to set up some procedure by which industrial companies with a progressive point of view might be given the guidance of experts in the biological sciences, and at the same time make possible for experiment station men a better comprehension of the possibilities in the industrial world.

The Division of Research Extension of the National Research Council called a meeting of representative men from the biological sciences and from various industrial plants. The purpose of the council was to encourage the organization of an agency which would meet a need not otherwise provided for. The group met in the building at that time occupied by the countil. It adopted a tentative form of organization, and it defined the purpose of the new Crop Protection Institute in these terms:

1. To promote the general welfare through the efficient control of injurious insects and plant diseases affecting all economic and ornamental plants and their products.
2. To promote efficient control of insects and plants injurious to man, domestic animals and animal products.
3. To support and direct research upon other problems of similar nature.

4. To further cooperation between scientific workers and the manufacturers of insecticides, fungicides and other similar materials, the manufacturers of appliances required for their use, and the manufacturers, packers and shippers of plant, animal and other products.

5. To assist in the dissemination of scientifically correct information regarding the control of injurious insects and plant diseases.

In its form the institute was set up as a definite entity, controlling its own destinies. Provision was made for a rather wide latitude of functioning, depending on developments as the institute got under way. The plans included authorization for setting up subdivisions under the institute, these subdivisions to represent various groups in industry. The plans included, also, a provision for carrying on specific research projects, each supported by a single manufacturer. As the institute got under way the latter procedure became the important and productive activity.

Memberships.—From the beginning provision was made for three classes of membership in the institute. By far the larger number are those who hold scientific membership, which is restricted to experiment station workers and others who are not employed in a commercial capacity. There are about 300 such members. Manufacturing companies were permitted to hold industrial membership. These have always been relatively few in number. Representatives of manufacturers could hold associate industrial membership. Here again the number has always been limited.

Significant functions of the Institute.—As the institute found its place more fully, its work crystallized around such undertakings as the following:

1. Studies of such materials as copper, sulfur and oils, to discover wider and better agricultural and household uses for their compounds and products.

2. Development of new sprays and dusts for use on plants, to protect them from insects and plant diseases.

3. Utilization of by-products of industrial manufacture.

4. Extension of the use of fertilizers, especially the more efficient utilization of fertilizer materials.

5. Discovery of other materials useful in the growing of plants, and development of their most efficient compounds.

6. Protection and treatment of food products, such as cereals, dried fruits and the like.

7. Development of substances for use on livestock, to control pests.

The aims of the Crop Protection Institute have a certain parallel to those of such an organization as the Mellon Institute. The work of the latter is concerned with development of new or improved products in industry, new methods of manufacture and the like, which are of benefit to the supporting company and to the public. The Crop Protection In-

stitute is concerned with the development of new or better sprays, dusts, soil treatments and the like, which should be of value to the company making them and which serve the public through better control of pests and through similar objectives. The Crop Protection Institute, however, is dealing with biological sciences and conducts its work in coöperation with experiment stations, utilizing their unique facilities, whereas the Mellon Institute is able to do much of its work within industrial laboratory walls.

Relation of the Institute to other research or professional societies.—Because of the fact that the initial invitation which brought about organization of the Institute was extended by one of the divisions of the National Research Council, and because of the council's continuing interest, provision was made by which the council names one member of the board of governors of the institute. Because of the manifest relation of the institute's work to that of entomologists, plant pathologists and chemists, provision was made by which the American Association of Economic Entomologists and the American Phytopathological Society each names three members of the board of governors, and the Association of Official Agricultural Chemists names two members.

These provisions have meant the selection of responsible and authoritative men to membership on the board. The advantage of this to the institute is manifest.

It should be made clear, however, that the institute is not organized as a division or a part of the Research Council, nor as a part of the entomologists' or the plant pathologists' societies. Neither the Research Council nor any of the societies is directly responsible for the activities of the institute. The institute was conceived as an independent organization, responsible to the aims and ideals for which it was established. It has been so maintained from the beginning.

Functions of the board of governors.—Control of the institute was vested from the start in a board of governors, consisting of nine men, selected as described in the preceding paragraphs. Since the institute was set up as a completely independent organization, standing on its own feet, providing its own finances, directing its own destiny, the responsibility of the board is necessarily directed to the welfare and ideals of the institute. Their responsibility is similar to that of the trustees of an educational institution or a research foundation. All of the institute's activities, procedures and policies are directed and controlled by the board. All fiscal matters fall within their jurisdiction. Since the personnel of the board changes rather slowly because of the fact that most members are named for a period of years, the institute has been able to follow a consistent, well-thought-out line of development.

A regular meeting of the board of governors is held once a year, usually at the same time and place as the annual meeting of scientific societies. However, the board transacts business throughout the year by specific letter ballot, and members of the board representing specific professions are in rather frequent personal contact and conference. Both of these customs are necessary because new situations and activities arise from time to time through the year. All transactions of the board are recorded

by the secretary. The official file of board action is maintained at the secretary's office.

Officers of the board.—Provision was made in the organization of the institute by which the board elects its own chairman. Later, by subsequent action, provision was made for a vice chairman, who assists the chairman. The board was authorized, also, to elect a secretary and a treasurer and later these two offices were combined in one.

Duties of the chairman.—From the beginning, with the consent and approval of the board, it became necessary for the chairman of the board to take the lead in contacts with industries. In this duty the vice chairman now serves as assistant.

This duty of establishing and maintaining contacts with industrial plants, both those maintaining projects with the institute and those who might maintain projects, is the most extensive and perhaps the most important work that the chairman is called on to do. Inevitably it involves conferences and discussions with various officers of various companies, sometimes with several officers in a single company. From these contacts the institute's program of research projects arises.

As procedure crystallized the board made its chairman responsible for the continuing integrity of budgets in the various projects under way. In order that this duty may be fulfilled duplicate records of expenditures are maintained in the chairman's office, verified monthly with the treasurer. For administrative reasons the chairman was made a member *ex officio* of each project committee, and as a rule attends meetings of these committees. As a further procedure the requirement was set up that any disbursement by the institute treasurer should be made only on authority of a voucher signed jointly by the chairman of the board and the treasurer. All records of institute research activities, including all data accumulated in research projects, are given permanent filing place in the office of the chairman.

The chairman reports to the Board from time to time through the year as the institute work progresses. A summary of the institute's activities in its various projects through the year is submitted to the board by the chairman at its annual meeting, or in advance of the annual meeting. This summary becomes a part of the official record of the board.

Project committees.—Early in its procedure the institute adopted the policy of setting up a special technical committee for each research project for which the institute becomes responsible. These committees represent the board of governors in technical direction of projects.

A committee usually consists of three men, and these are chosen as a rule from among experiment station workers. They are selected for their expert knowledge of the subject matter to which a given project is related. The chairman of a committee is automatically either the head of the appropriate department where a given project is placed, or such member of the department as has charge of the department's activities in the field concerned. Thus, it will be seen that choice of location for a new project, and choice of a committee chairman, are interrelated. In selection of committee members the judgment of the committee chairman is given due weight. Consultation is had, also, with other men in

the same field of science, particularly members of the board of governors who represent that field. Eventual announcement of the location of a project and the choice of project committee is made by the chairman of the board, but the process of choosing a location and selecting committee members is a matter of conference, sometimes long continued, on the part of the men indicated above.

The function of a project committee is explicit and broad. It is charged with the responsibility of planning the research work in the project in question, the selection of the research man or men to be employed, and the sound appraisal of the results derived from the studies in question. The committee is a functioning body which has both powers and responsibilities on behalf of the institute.

Preliminary contacts.—As the work of the institute has developed it has been found that its relationship to industrial companies represents three distinct types of activity. The first of these involves preliminary contacts. In the complex manufacturing world there are many industries that might reasonably have some connection with the problems of the entomologist, the plant pathologist, the agronomist and others in related work. As a matter of fact, one never knows where a new contact may be found that, eventually, will result in a substantial advance for agriculture, for the scientist, and for the public at large. The institute, largely through the chairman of its board, assisted by the vice chairman, is continually making new contacts and searching for new leads that will result in a program of research from which results of value to all concerned may come.

Tentative studies.—The second line of activity is that of tentative studies which do not at the outset reach the scope of organized projects. The purpose of these is twofold. On the one hand they are likely to disclose new materials that otherwise would not be thought of. On the other hand they are intended to protect the institute itself from embarking on a substantial research project which would not actually be of sufficient promise to be worth the institute's efforts or the manufacturer's financial support.

Sometimes at the beginning these preliminary studies are financed by the institute itself from a reserve fund which it has gradually built up, partly for this purpose. Sometimes they are financed by small appropriations from the manufacturers concerned.

It should be pointed out that the realm of chemical substances which might conceivably be useful in agriculture, is large. Only a few of these, relatively speaking, have been explored. The majority have had no competent attention. For example, in the dyestuff industry there are hundreds of organic chemicals among which a new fungicide or a new insecticide may well exist unsuspected. To an increasing degree the institute is functioning as a means of securing orderly exploration of various extensive chemical groups.

Formal projects.—The third type of activity of the institute represents its largest functioning. This is the organization and direction of substantial research projects. In this work the institute has arrived at a definite procedure which is well crystallized and which has been found

to constitute a logical, productive and trustworthy plan. The several stages in the plan are as follows:

Initial examination.—The first essential is to determine whether a proposed project represents a sound and logical field of endeavor. Decision as to this is reached by exchange of views among scientific workers who have expert knowledge of the field in question, especially among those members of the board of governors whose work is allied to that of the proposed project. If a proposed project ought to be a tentative inquiry rather than a fully-organized project, the institute wishes to avoid too great a commitment. In such case it is following the practice of recommending to the manufacturer that only preliminary studies be undertaken.

Proposed plans and budget.—Granted that a proposed project is apparently sound and promising, possible plans and budget are discussed. In arriving at tentative plans one or more members of the board whose field of work is allied to the proposed project are called into consultation. Plans may be submitted to other workers who are not members of the board. The intent is to arrive in advance at rather definite ideas as to the scope of the project, the method of attack and the estimated cost. All this in turn is discussed with the industry concerned.

Submission to board.—If the project is assured necessary financial support it is then submitted to the board of governors for their formal approval or rejection. As will be noted, the plans have already been studied by technical, disinterested men in the field of the proposed project. One or more of the board members representing that field have taken part. The budget has been carefully considered. All this having been done in advance, the board then authorizes or declines to authorize the proposed project.

Agreement for project.—If the project is authorized, an agreement is executed with the supporting industry. This agreement defines the object of the project and provides that the necessary funds will be deposited with the institute periodically, in advance. It provides that the board of governors of the institute "through its officers and a special committee on this project, will direct the disbursement of funds, the appointment of investigators, and the publication or other disposition of results, and in general will be responsible for the carrying forward of said project."

Further provisions of the contract read as follows:

> Progress reports will be rendered by INSTITUTE to [an industrial company] at intervals. A final report will be rendered on completion of the work.
>
> Any report, when published by INSTITUTE, may be quoted by [an industrial company] as desired, but results of this project will not be quoted in any other manner, except by permission of INSTITUTE.
>
> A report by INSTITUTE concerning a product is understood to apply only to the exact product submitted. If the composition of a product is changed INSTITUTE will be notified, and reports by INSTITUTE as to the original product will not be

quoted with reference to the new product, except by permission of INSTITUTE.

An institute contract is subject to renewal if such renewal is desired both by the manufacturer and by the institute. If substantial changes are to be made in the nature of the work the plans and budget are again submitted to the board of governors for their approval, as would be the case with a new project.

Details of the form of printed contract used by the institute have been worked out and modified from time to time as experience indicated changes or improvements. The printed form in use has been officially adopted by the board of governors.

Selection of location and committee.—The agreement having been signed, work is usually to begin as soon as possible. The first task is the choice of location for the work and choice of a technical committee to direct it. As indicated above, these two are interrelated because the chairman of the technical committee is always the responsible scientist in the university, experiment station or other institution where the work is located. Following the procedure indicated earlier in this paper, a committee is selected and the location of the work is determined. In choice of location various considerations are necessarily taken into account by the members of the institute board who are most concerned in a given project, including such matters as geographical location, laboratory facilities, field plots required and so on.

Selection of research worker.—At the same time the technical committee and appropriate members of the board consider choice of a man, or men, to set to work on the new project. The institute has in its files the qualifications of various men. A position on the staff of the institute is a good opportunity for a man with capacity. Usually a project requires a man who not only has had adequate technical training but has already demonstrated his ability to plan and conduct a substantial and productive piece of research.

An institute employee engaged for work on a given project is paid at a rate determined by the project committee and based on the technical requirements of the work to be done, the training required, and the prior experience necessary. Appointments are made for one year unless the work is to run a shorter length of time. The salary of men employed on projects ranges from $1800 to $3400 a year, with an average of approximately $2400.

Meeting of committee.—The research worker having been selected, a meeting of the technical committee is called. This meeting may take place at the experiment station or university where the work is to be located, or it may take place at some point where representatives of the supporting company, especially its research department, may conveniently attend. The purpose of this meeting is to work out detailed plans. While final authority to determine what shall or shall not be included in plans lies with the institute's committee, it is the practice to seek expression of views on the part of the supporting industry, especially its technical men.

In the experience of the institute, this procedure, whereby a technical

committee invites attendance and participation on the part of representatives of the industry concerned, is invariably helpful. The men representing the industry know their own materials. They know what by-products are available, what modifications may reasonably be made in the constitution of materials. They know whether it is possible or not to produce a new material to meet certain specifications. By participating in the discussions of an Institute committee a manufacturer acquires a feeling of coöperation with scientific men who are not employed in industry. If a new project is developed, a manufacturer has a wholesome knowledge of its limitations as well as its possibilities.

Progress of work.—The institute committee having concluded its meeting and arrived at detailed plans, the way is now clear for the man or men employed on the project to begin work. This usually is the next and immediate step. As the man gets under way in his new task he draws up a report each month showing the progress of his efforts. Copies of this report go to the members of the institute technical committee for their critical examination. A copy goes to the supporting industry. At the end of three or four months another meeting of the technical committee is called. Details of progress to date are considered. Modifications in plans are debated. A program for the next few months is worked out in detail.

Thus, the work proceeds throughout the life of the project. When a given project has, apparently, reached completion it is brought to a close. Any unexpended balance in the project fund is subject to return to the industry that has been supporting the project.

Publications.—If an investigation has reached a stage warranting a printed report, data are assembled for a bulletin. This bulletin is usually the equivalent in form and scope of a research bulletin issued by a state experiment station. Copy for the bulletin is critically reviewed by the institute's technical committee. The channel of publication may be in the regular series of bulletins of the experiment station where the work is done, or may be in a technical periodical, such as the official publications of the plant pathologists, the entomologists or the chemists.

It is usually the procedure to print several hundred separates which are given an appropriate number in the bulletin series of the institute.

In any case due credit is given to the experiment station or university which has provided facilities for the project.

Permanent equipment.—In all of its work the institute has followed the policy of avoiding purchase of substantial items of permanent equipment. When a project is placed with an experiment station it is assumed that the station will provide ordinary equipment for the worker in that project, in the same way in which it provides such equipment for regular members of is own staff. If some special item of equipment is necessary which would not be useful to the station in any other phase of its regular work, special provision is made to provide such an item, usually on a temporary basis. The item may be secured by loan, it may be provided by the manufacturer supporting the project, or it may be purchased under some suitable arrangement with the manufacturer. Such a provision, however, is exceptional.

In the somewhat rare cases where an item of permanent nature has

been provided, its disposition on completion of the project depends on the circumstances of the case. If an experiment station has contributed heavily, the item may be left with the station, in appreciation of its support of the project. If an item has been provided through special arrangement with the supporting company, it may be returned to the company, should the latter desire it. The point should be emphasized, however, that purchase of permanent equipment has been contrary to the policy of the institute from its beginnings.

Purchase of supplies.—In any institute project, necessary minor purchases chargeable to the project fund are made by the chairman of the project committee or on his authority. Bills for such purchases are forwarded to the chairman of the institute board, who enters the purchase on an institute voucher, approves it and forwards it to the institute treasurer for his approval and for payment. If a major purchase is necessary, the nature and amount are communicated to the chairman of the institute board, who is responsible for seeing to it that expenditures are kept within the project budget, and who in general is required to maintain the work of the institute on an economical basis. There is a constant check on all expenditures to maintain them at a minimum level consistent with adequate research.

Financial system.—Each project that the institute undertakes is handled as a completely separate fund with its own ledger account. Disbursements from this fund are made only on vouchers which specify what the disbursement is for, and which must bear the signature of the chairman of the institute board and the signature of the institute treasurer. With a properly certified voucher in hand check is drawn by the institute treasurer in payment of a given account and the amount of the check is charged against the particular fund involved.

Each fiscal year all financial transactions of the institute in all funds are examined in detail by a certified public accountant. All vouchers are checked, all book entries are examined in detail, all balances are verified, and the actual resources in the institute treasury are checked and verified. A certified report is then made to the board of governors of the institute. This report is available for detailed examination by members of the board, or by other interested parties who have proper reason for access to it.

General expenses of the Institute.—Contracts made by the institute with manufacturers provide that 10 per cent of the fund provided by the manufacturer for a given project is available to the institute for its general expenses. This 10 per cent is deducted from the fund and is transferred to an institute general account, from which proper expenditures are made on the same system of vouchers as that used in the case of each institute project fund.

The institute general fund each year totals $5000 to $5500. Out of this all general expenses are met. These include the following: travel expense of members of the board of governors in attending board meetings; allotments to the chairman, vice chairman, secretary-treasurer and stenographer; travel of the chairman and vice chairman in the conduct of institute business in the course of necessary contacts with existing

and prospective supporters of projects; purchase of supplies; payment of telephone and telegraph charges; and mailing expenses. The maximum so far authorized by the board in any one year for allotments to the chairman, vice chairman, treasurer and stenographer has been $3300. These various expenses indicated absorb most of the institute's general fund, year by year. In ordinary years, however, a small undisbursed balance remains, which under favorable circumstances may amount to $500.

Reserve fund.—Undisbursed balances from year to year have been placed in a reserve fund. This fund, in the course of the fifteen years that the institute has been operating, now amounts to approximately $8000. The purpose of this reserve is twofold:

First, out of this reserve the institute is able to do a certain amount of exploratory work with new materials which might be of sufficient promise to warrant a substantial research program. This plan also protects the institute from undertaking a substantial project with some material which is not of sufficient value to warrant the Institute's interest.

Second, the reserve serves as a safety factor. The volume of business transacted by the institute is likely to vary from year to year. In any year in which it falls off, the income from the 10 per cent provision in the contracts also falls off. It is considered to be sound financing to have a reserve in the treasury which may meet such a contingency.

The rights of supporting companies.—Under the institute's plan of operation, a company that supports a project with the institute is given prior rights. This is definitely a part of the institute procedure. Conceivably, industrial companies might contribute funds which would be combined and used for research the results of which would be available to anybody. There is manifestly no objection to this plan, if it can be made operative. But the institute operates on the theory that a manufacturer who develops a new product, and who provides funds for its thorough study and appraisal, has a logical prior right in such a product.

It is to be noted that if a product is effective, as disclosed by thorough investigation, the manufacturer must still invest heavily in order that the product may be available to the public. In most cases such investment would not be possible unless the manufacturer possessed prior rights. If the investment were not made, the public would never have the benefit of the product in question, because no one could afford to make the product available.

As a rule any material which the institute is called on to study has been devised in the research department of a company. Thus, it is already the property of that company. The function of the institute is to provide expert, thoroughly-organized investigation which will determine in a disinterested and authoritative way what a new product will and will not do.

Thus, in general, any question of patents is settled in advance through developments that have already been made by a supporting company. Modifications of a product, as indicated by its performance, are also devised by the research department of a supporting company.

The institute asks that a full statement of composition be made available to its technical committee, in order that its research program may be intelligent and well considered. There has never been any difficulty about this.

Rarely a situation arises in which a man employed in an Institute research project assists in the invention of a new product. This has seldom happened. When it does, it is considered that the institute shares credit with the supporting company in the devising of a new product, and provision is made by which, if the new product eventually is marketed, the institute shall receive a nominal percentage on gross sales, this money to be devoted to the institute's general scientific advancement. Up to the present time no revenue has accrued to the institute from this provision.

Why the Institute functions to advantage for a manufacturer.—Most large industrial companies have research laboratories well provided with equipment and with technical experts. These experts, however, are not usually in position to possess detailed knowledge of plant or animal life, or to appraise the performance of materials when applied to plants, or animals, or soils. Also, such research laboratories cannot well command the extensive biological equipment or the equally extensive field plots, orchards and the like, which are required for competent study of the performance of a given material. The institute, through its relationship with experiment stations, is able to make suitable arrangements by which the right technical knowledge and appropriate facilities can be brought to bear upon the biological performance of a new material or upon similar problems.

Other advantages are evident on analysis. Thus, a project placed with the institute enjoys from the beginning the advantage of the institute's broad experience, extending through a period of fifteen years, in the successful planning and direction of research and development programs. A supporting company is kept in touch with the progress of the work through the institute's system of regular reports. A man employed on a project on behalf of a manufacturer has contact with the specialists of an experiment station staff, and has access to department and station libraries. Since the institute is able to establish coöperative relationships with workers in various states, a manufacturer has an important advantage in the fact that a new product can be given experimental study in various parts of the country, representing various climatal conditions. Since the institute is purely a fact-finding and administrative organization, which has nothing to sell or to promote, its appraisal and recommendations are unbiased.

Why the Institute functions to advantage for an experiment station.—It is entirely possible for an experiment station to receive funds direct from an industrial company, to be used in studies of that company's products, or in other similar work. This has been the practice in a number of stations for a considerable period of years. If in a given case it is the better way to accomplish the desired results, it should remain the practice.

However, there are advantages to an experiment station in contacts

made through the institute, rather than direct with an industrial company. The fact that the institute plans and conducts its work through technical committees, broadly selected, means that an unusual degree of thoroughness can be attained in the planning and prosecution of a given piece of work. This is rather certain to ensure scientific results which can constitute a comprehensive and authoritative publication in the experiment station's bulletin series. The fact that the institute undertakes the necessary contacts with a supporting industrial company relieves an experiment station of various responsibilities. Also, the fact that the institute is steadily more and more in touch with branches of industry that may properly provide funds for research, means that new activities in the way of thorough research programs are constantly being developed.

Achievements of the Institute.—A part of the genuine accomplishments resulting from the institute's work are of a general nature, as distinct from the development of new spray materials and the like. Thus, the institute has been in part responsible for the fundamental research that has taken place in the last twelve or fifteen years in the nature and performance of various basic substances. An institute program initiated some of the research that has added to our knowledge of the properties and performance of sulfur. Institute projects have brought about notable advances in our knowledge of copper and copper compounds. Basic search of petroleum derivatives has been forwarded by institute projects, especially in territory east of the Rockies. Fundamental advances have been made in knowledge of compounds derived from the heavy metals. Through institute projects exploration of various groups of organic chemicals has been initiated.

The work of the institute has brought about among manufacturers a new appreciation of the value of research from a biological point of view. Progressive companies have long been aware of the importance of industrial research in their own plants. A number of the larger industries have been led to an equal understanding of the importance of biological research, as well as its difficulties.

Specific new developments.—Specific new materials developed in whole or in part through institute projects constitute a considerable list. Thus, much of the development work with the household insecticide Flit was done through the institute. The dormant oil spray Dendrol, and the summer oil spray Verdol, are the results of institute projects. Other developments include the following: the new fumigating gas Proxate; the colloidal copper compound Coposil; a further colloidal copper compound now in its final stages of development; an impregnated tape for use in wrapping nursery grafts; flotation sulfur; improved formulae for cattle sprays; the use of dilute sulfuric acid in large-scale weed control; the oxydized oil Penetrol; a series of new materials known as Dowsprays; the utilization of basic zinc arsenate in codling moth control; the use of copper sulfate in fertilizers. Institute work resulted in noteworthy contributions to our knowledge of crown gall. Institute projects have yielded important information concerning the performance of oil sprays on plants, the inflammability of various mixtures of gases, the performance

of chlorinated naphthalene, and methods of determining and rating toxicants in spray materials.

Contacts among scientists.—Through the institute friendly contacts between the technical men in industry and those in the biological sciences have been furthered. The result of this has been a greater understanding on the part of industrial men as to the nature and significance of the work done by the experts in experiment stations, and equally better comprehension on the part of the experiment station men as to the problems and achievements of the technical men in industries.

Opportunities created.—The work of the institute has created opportunities for a substantial number of men in entomology, plant pathology, and allied sciences. An appointment as a research man with the institute is a desirable connection. It gives opportunity to do an orderly piece of work in coöperation with a technical committee composed of men of experience and broad knowledge. It affords contact with technical experts in industry, from whom stimulating ideas are certain to be derived. A man employed on an institute project is not called on to conduct courses, answer correspondence, or in other ways to spend time on activities which are not directly related to his research. If he is resourceful and if he has had adequate training, he is in position to establish himself as a worker capable of productive effort. The results of his work, if they are of broad significance, are usually published in established channels and in the bulletin series of the institute. Up to the present time the institute has handled approximately seventy-five projects of sufficient scope to be significant and has employed approximately a hundred different men in its various undertakings.

Conclusion

In the fifteen years that it has been at work the Crop Protection Institute has handled a total volume of research comparable to that of a state experiment station of moderate size. It has printed and distributed a series of research bulletins, some of them extensive in scope, totaling to date fifty-four separate titles. Others are in press. It has established and maintained productive relations with a long series of industrial companies, and has found them uniformly appreciative of the institute, its thoroughness, its carefully devised procedure, its painstaking handling of funds, and its authoritative standing. It established close and cordial relations with experiment stations, and has found them ready to welcome institute projects as sound and well-managed pieces of research and development, which add to the output of a station and usually result in a body of data that form the basis of a creditable scientific paper or bulletin.

The institute has had many new problems to solve. There was no organization of similar plan and scope from which to pattern. It has approached these problems thoughtfully, has given them thorough study through the continuous services of its officers and its board of governors, and in this way has worked out their solution. The fact may be stated with confidence that it is today filling a function which represents a genuine need, and which no other plan of organization has attempted to

fill. Continuous effort day by day and week by week has been necessary to accomplish this. The result is the institute as it stands today.

THE COMMERCIAL ENTOMOLOGIST

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An invitation from the president of our Association to discuss the field of commercial entomology and the role of the trained entomologist in that field offers an opportunity to clarify, perhaps, some of the misgivings concerning the profession of economic entomology and its desirable relationship to the business world.

Reluctant at first to accept the invitation, it was suggested that my thirty-three years of experience in federal, university, state and commercial entomology should be a melting pot from which some conclusions could be drawn to define and explain the field of commercial entomology and its relationship to allied groups of science.

The subject provokes many angles of thought and reaction, and doubtless many phases of judgment must be considered and weighed in the discussion of a rising branch of entomology, relatively new and imperfectly comprehended by our membership.

Therefore, wishing to present a more accurate cross-section of this subject, the writer prevailed upon more than a dozen of our leading entomologists with commercial firms to submit their conclusions on the more important questions involved. From these letters so kindly offered I shall draw some thoughts and occasionally shall quote verbatim.

Definition.—A commercial entomologist may be defined broadly as one having a fundamental training in entomology and allied subjects, who is employed in research, educational or sales promotion service by a commercial concern or by any person or group of persons in commercial production. The term "entomological engineer" has been suggested as a dignified title for certain types of commercial work, and it might well be adopted into our language and literature, thus conveying to the public more accurately the idea of an immediately available technical service so desperately needed at times to prevent or eliminate losses from the ravages of insect pests.

The generally accepted idea of a commercial entomologist as one who sells insecticides or is engaged in pest eradication work for commercial concerns must give way on mature thought to a much broader concept.

A changing attitude.—The stigma that was attached in earlier years to an entomologist in the employ of commercial concerns fortunately is rapidly disappearing if we may judge from the relatively large number of applications for positions received from state and institutional entomologists during very recent years by leading commercial concerns in the business of manufacturing and selling insecticides. Perhaps this condition may have obtained through reduced budgets, which may have rendered state positions less desirable and less secure.

It is rather difficult to understand the narrow-minded attitude of many entomologists (and plant pathologists) toward their fellows who

have accepted offers in the commercial field. In contradistinction, chemists and engineers in government or state work who have accepted offers from leading manufacturing and chemical companies are congratulated on their good fortune, and henceforth carry a larger measure of respect from their contemporaries. Perhaps the attitude of our scientists would be more tolerant in this respect if our government, state and institutional employes in science realized that the entire support of themselves and their work is dependent on taxes, funds and bequests accumulated largely from commercial concerns, or from individuals in minor commercial enterprises such as animal and dairy husbandry, poultry and fruit growing and general farming.

The agricultural county agent whose salary is paid in part by a group of farmers within a certain geographical area could be classed as a quasi-commercial specialist. Any entomologist in state or station work who receives a definite portion of his salary out of special funds from any private group for services, such as control of mosquitos, fruit insects, sugar cane or pineapple pests, truck crop pests or pests of processed agricultural products, could be considered in a quasi-commercial status.

Criticism of commercial men as well as institutional entomologists is often based on human failings which vary with the individual. Some have ridden a hobby or have been surrounded by four walls so long that they have developed blind spots which interfere with their proper vision and judgment of values.

Group similarity.—We recognize among the federal, institutional, state, county and city entomologists those engaged in administration, teaching, research, experimentation, consultation, extension and control. Among the commercial entomologists we find the same groups engaged on their various problems in a most serious manner, for their efforts must be successful and conclusive, and no mistakes can be made. "Mistakes or errors of judgment can be made by government, state and institutional workers with a considerable degree of impunity," but not so in the commercial field where the profit and loss columns are placed glaringly side by side. "A commercial entomologist *must* make good in his job, but unfortunately for the taxpayer and others, the federal, college and station worker is not compelled to produce to the extent of his cost to that institution." We recognize there is no definite yardstick to measure his value, but we know in many cases the reasonable yardstick must shrink noticeably, or the worker be stretched in order to match it. "Errors have occurred in the choice of entomologists in the commercial field, but let us consider how many workers in government, state and institutional work are only partially successful or are near-failures."

I do not wish to make too many invidious comparions between the commercial and non-commercial entomologists, but certain factors may well be mentioned as amenable to desirable change.

A commercial entomologist, if successful in his job, cannot saunter into his office at 9:00 a.m., read the morning paper, look after some letters, make a few determinations of well-known pests, dictate recommendations for control, perhaps read a few articles of scientific interest, draw his work to a close about 4:15 and prepare for departure at 4:30 p.m.

without further thought of work—a program which too frequently obtains in some institutions. This characterization, I am glad to report, does not apply generally to entomologists, many of whom are really overworking without needed diversion, but the tendency to follow such programs is all too evident. Many of our older entomologists whose work, often under adverse conditions, we are bound to respect and admire, carried on their office, teaching and experimental work in regular hours and "found time out of hours at every opportunity to collect widely and specialize on certain groups to the everlasting benefit of our science."

The commercial entomologist whose duties are largely in a sales capacity and who may combine office work with travel, is out and away at all hours, working earnestly at top speed, testing his knowledge and abilities with his competitors in a friendly way, approaching business men, dealers, distributors and consumers without any club of authority or prestige of government or state supporting him. In common parlance, he is largely "on his own." He must convince his prospect as to the desirability of his products and often must estimate the customers requirements, determine freight rates, discounts to dealers, and manner, time and place of shipment and delivery, not forgetting the credit rating of his customer. If he sells for the horticultural trade, he must understand the spray practices and recommendations in the various states (and sometimes these vary too widely); he must know the compatibility and safety of chemicals in combination or in successive applications through the growing season and the dormant period. It is imperative that he recognize common pests and their relative importance in various sections of the country, and be able to help his customer in every possible way. One of our well-known state entomologists observes that "after the federal and experiment station entomologists are through the commercial entomologist has the last say."

Facilities for action.—Certain advantages accrue in the commercial field not generally found in government and state work which offset some disadvantages. Action and results are called for in the commercial field, since these concerns must be self-supporting and make a small margin of net profit to exist.

As distinguished from much of the federal and state work, which may be delayed by months of committee hearings and budget preparations, a major project with a commercial concern may require a ten to sixty minute conference of officials, who discuss the economics of the problem without alibi. If favorable, every wheel is set in motion at once. Authorizations, budgets, purchases and plans without red tape are issued and the work may start at once, with travel funds advanced by the company.

Leading commercial concerns demand that their employes dress well and appear neat and presentable; engage accommodations in the better hotels; meet the better class of people and uphold the reputation of the company.

At this stage in our discussion I wish to point out a misconception of salaries for entomologists starting in the commercial field, which has been promoted in certain institutions teaching entomology. Commercial

concerns demand results, and until they appear salaries at the outset may not be attractive, but advances may be more rapid than in non-commercial fields.

Friendly enemies.—With the keenest rivalry often existing among commercial men there generally exists a friendliness of the highest order, and a respect for each other's judgment, policies and interests combined with a frankness without rancor, which is not to be found generally in the non-commercial groups. Opportunities for travel enable the commercial entomologist to become more conversant with many area conditions and local control methods than is possible with the worker whose travel is largely limited to one state. Many really large fruit growers place more reliance in the commercial entomologist who supplies his spray materials, than in the state experiment station and extension entomologists. This situation is often the result of the limited experience and narrow viewpoint of the latter groups.

The better commercial entomologist by means of up-to-the-minute discussions of problems and projects, methods and materials, workers and results, becomes at once a scientific news reporter; a constructive critic of research; a stimulator of new projects; an analyst of the economics of pest control; a judge of the reactions of men in the field; a coordinator of ideas and projects; an accessory worker in extension and a timely "clearing house" and "relay" for economic entomology.

Training for the commercial field.—Following these generalized statements let us now give consideration to the training and personality desirable for the commercial entomologist, as well as his opportunities for service in the future. I shall quote frequently from the aforementioned letters, all of which laid emphasis on training.

First and foremost the man who would be successful in the commercial field generally (except possibly those in pure research) must have personality and good judgment "to develop effective and harmonious contacts with all sorts of persons of extremely variable temperament and points of view, such as college and experiment station men, business men, farmers and others." "He must be able to talk the language of the scientist, of the business world, and put himself on the same plane in conversation and sympathetic viewpoints and understanding with the man on the farm." "He must be as nearly as possible an effective combination of research scientist, instructor, extension worker and business man," and his ability to adjust himself to these varying situations is vital to success.

OUTSIDE CONTACTS.—The student or entomologist who would enter the commercial field should be encouraged "to develop personality by generous contacts outside the classroom and laboratory, such as athletics for some, or literary societies" and extra-curricular activities on the campus. It is likewise desirable that he maintain contacts with the business world whenever and wherever possible, so that he may become acquainted with methods and ethics of good business. "In the final analysis, of course, personality is one of those abstract things that the person either has, or has not." "No amount of training, in some cases probably, would ever change an essentially drab, colorless person into an

attractive, interesting individual, but there are others whose essentially pleasing personality may be obscured by excessive self-consciousness, timidity and diffidence." In such cases these handicaps may be overcome to a great degree by proper experience.

"The commercial worker, fully as much as any true scientist, must be fair minded, honest, accurate." "He must approach his work in a spirit of absolute scientific honesty . . . if he would be truly successful." "He must respect his job as an opportunity for honest and valuable service, . . . contributing to the advancement of science and welfare of his constituents, as well as in any type of entomological work in which he might be engaged." "There is no reason for a commercial entomologist to feel that his work is on any lower plane, in any respect, than the work performed by his experiment station or college contemporary." Men entering the commercial field should have a practical turn of mind; should be adaptable and have sufficient courage to support their work under all fair conditions.

"One of the outstanding changes that occur to an experiment station entomologist, after he enters the employ of a commercial worker, is his attitude toward commercial concerns," says the entomologist of one of our large companies. While the commercial man is vitally interested in the sale of his company's products, he must realize that the success of continued sales of any insecticide is dependent upon the results as secured. The same entomologist emphasizes "the need for more careful selection of candidates for experimental work, so that the men who enter the experimental field might eventually be well qualified to enter the commercial field." "Consumers of agricultural insecticides will respond more quickly to new and improved methods of insect control if development in sales promotion work is done by entomologists in the employ of manufacturers who appreciate the viewpoint of experiment stations and manufacturers, resulting in closer cooperation."

SCIENTIFIC TRAINING.—Training for commercial entomology should be even broader than is generally prescribed for entomologists and should include "a well-grounded general agricultural education, with specialization in entomology, botany, plant pathology and other closely related science, particularly of a biological nature"; and in addition organic and physical chemistry, economics, sociology and psychology. He should have a general knowledge of plant physiology, soil ingredients and the effect of various fertilizers on plant growth.

A thorough course on insecticides, which are so lightly dealt with in many of our entomological courses today, is absolutely necessary if the commercial entomologist is to enter the field without handicap. He should be acquainted with the various well-known inorganic insecticides, their reactions to insect and plant life, their compatibility and the effect of exposure to heat and moisture. The newer organic insecticides should receive unusual attention at this time, as the demands for insecticides of this type are rapidly increasing and no one knows where the present studies of these products now in progress will lead during the next decade.

It is not always possible in our institutions to secure the proper train-

ing on oils and their derivatives; however, this important group should receive increased attention as even now more derivatives of petroleum are being produced, but not as yet on the market, which may approximate the nicotine and pyridine and other similar groups having distinct toxic qualities. The woeful lack of knowledge on the part of many of our entomologists of petroleum products is unfortunate. Stress has been laid on type—whether paraffin, asphalt or mid-continent—on color, end points, distillation ranges and evaporation. On the other hand the true value of the hydrocarbon compounds is not well understood, nor the value of the napthenic acids and soaps contained in certain petroleums. Some of these naphthenic acids and soaps have distinct insecticidal values in addition to the insecticidal property of the oil as such.

In addition to the regular course of training for an entomologist it is most important that on every opportunity during vacation periods he engage in field work of an experimental nature, thereby gaining experience and broadening his conception of the general field of entomology and its application to the business world. Too many students in past years have been granted higher degrees without the necessary field work following their bachelor's degree to fit them for advanced investigation and experimental work. In this connection I must re-state that in the commercial field there are opportunities for administrative, teaching, research, experimental, consulting, extension and control work. Some or all of these positions are to be found with the larger commercial concerns.

One of the older entomologists, whom we all respect, now with a commercial concern, believes that "the commercial entomologist, using this term in the ordinary sense of the word, should have just as good training, if not a broader one, than the presumably scientific investigator devoting most of his time to economic problems and having little or no relation to commercial activities. It is my belief," he continues, "that many of the so-called commercial entomologists realize to a greater extent the necessity of giving attention to factors other than the purely entomological type than is realized by the general economic entomologist."

A commercial man with one of our large corporations "believes the requirements for success in commercial entomology are more exacting, and call for a wider scope of training, experience and essential personal characteristics than in other lines of entomological work."

The successful commercial entomologist never closes the avenues of research because of his personal opinion. "He must be open minded, honest, accurate and ready to give consideration to every problem of merit that may be offered." "He should be familiar with developments in competitive fields," and competitive products, and refrain from unjust criticism of competitors.

Ability to distinguish, at all times, confidential information and trade secrets from that which may be publicised to promote his company's interests, is highly important. "The commercial man need not compromise with untruths, unfair competition or unethical tactics in order to give loyal service to the company which employs him." "The commercial entomologist at times is forced to fight but he can always fight fairly"

and he does not harbor the jealousy occasionally found in non-commercial science groups.

Economic entomology during the past quarter of a century has been so definitely directed toward the solution of problems of the farm and ranch that many magnificent opportunities to serve the business world have been overlooked. This trend probably has developed as the result of the influence of our agricultural colleges where the leading courses in entomology are offered to students. Many of these agricultural colleges are operating in conjunction with the experiment station activities, which influenced this trend still more. There are remarkable fields in economic entomology yet to be developed, wherein the business world, manufacturers or processors of materials and even human living conditions can be served.

Outlook for the future and opportunities.—The average federal and state entomologist is largely oblivious to the demand for insect control information in the large centers of population. They scarcely realize the enormous losses finally resulting to products of the field after processing. This applies particularly to cereal products of all kinds, as well as dried fruits, nuts and seeds. The problems of household insect pests are amazing and the losses aggregate enormous figures.

On December 29, 1932 there was organized The Society of Industrial and Consulting Entomologists. A constitution adopted December 27, 1934, declares its objects to be:

1. To promote the welfare of entomologists engaged in industrial, consulting and commercial insect control work.
2. To disseminate among its members information on the control of insects.
3. To standardize practice in industrial, consulting and operating entomology.
4. To assist in the placing of entomologists in suitable industrial, consulting or operating positions.
5. To further healthy cooperation between the members of the society and official entomologists.
6. To correct abuses whereby industrial and consulting entomologists suffer from ill-advised publications, faulty reports and other untoward actions.
7. To investigate and advise on the proper training of entomologists intending to enter industrial or consulting work.

This society, in addition to a president, has two vice presidents concerned with the *industrial* phases and the *consulting or operating* phases respectively. It is the hope of this society, in the near future, to be accepted as an integral part of the American Association of Economic Entomologists, and I believe that so long as they maintain the present high standard for membership that they are eligible as a group to the national body.

There is also a National Association of Exterminators and Fumigators with a considerable membership of operators. Not necessarily having had any specific courses in entomology, yet many of these men are very capable and use satisfactory methods for control of pests of

household, hotels, apartment houses and factories. In fact I question whether ten per cent of the federal and state entomologists could accept a large contract for clearing insect vermin from a 5000-room building with as great assurance of success as some of the so-called untrained exterminators.

It seems especially unfortunate that the trained entomologists have not perceived the opportunities to use their training in these fields. For instance, it is estimated that there are more than 100 exterminating firms in New Jersey and there are 264 pest exterminators listed in New York city alone. Most of these are single operatives with a small clientele. There are, however, a considerable number who employ from one to 50 men. In the entire United States there are estimated to be 1100 exterminating firms, and their work embraces all classes of pest control, including household pests, moths, termites, spiders, carpet beetles, powder-post beetles, silver fish, ants, bed bugs, fleas and the ever-present rats, roaches and mice. Contracts by these firms for exterminating purposes are generally made on the yearly basis and the amount of money collected for this work is astonishing. A question which is outstanding at this time is to what extent will the trained entomologists, who are capable of handling business matters and working under business conditions, enter and build up this field in a substantial and praiseworthy manner. Why permit any "tramp operator" to spread poisons and diffuse poisonous gases in thickly populated sections of our cities, or in factories producing food-stuffs?

The situation is becoming rather acute in some cities, in view of several fatal accidents which have occurred from poorly managed or misunderstood fumigation methods. Some of the members of the Society of Industrial and Consulting Entomologists, particularly Mr. I. L. Ressler, the president, has averted several serious situations pertaining to pest control by delaying the passage of certain discriminatory ordinances, or by revamping such ordinances in accordance with sane pest control methods. It seems that the time has arrived for trained entomologists to awake to the possibilities of extending their knowledge of pest control to the larger centers where it is in demand and where losses warrant payment of reasonable fees for careful and successful work.

It would seem that too much attention has been paid to the insect troubles of the farm and ranch. No other industry has had so much patronage from government and state agencies forced on them as has been the lot of the farming groups.

Great opportunities for the trained economic entomologists are available in pest control as tree surgeons, as forest entomologists for lumber concerns and paper manufacturers dependent on forest supplies. City park departments everywhere are in need of trained entomologists with administrative powers. Similar opportunities are available with large fruit ranches and fruit processing companies. Cereal food manufacturers, manufacturers and processers of tobacco and milling companies, cotton plantations, pineapple and sugar cane growers are already employing specialists in entomology.

As exterminators of various insect pests, large associations of grocers,

furriers, woolen, mattress and bedding manufacturers offer genuine opportunities. Likewise there are opportunities for extermination work on large scale with realty firms controlling apartment houses and dwellings. Hotel associations, factory groups and chain stores likewise offer opportunities for supervisory pest control work. Ship owners and railroad transportation companies have problems of tremendous interest and difficulty in controlling pests on public carriers.

The future holds in store many leads for entomologists which have not been generally appreciated by the members of our association, and I trust that this paper, with the kind aid of a number of our commercial group, has placed before you a new conception of these so-called "outer fields." It is the hope of the commercial group that our teachers of entomology and allied subjects will bend their efforts toward those phases of pest control which concern more generally our large centers of population, and prepare their students for the work which is so different from the insect problems of the farm and ranch.

One of our commercial entomologists writes as follows:

> I am glad to say that I believe that most of the commercial entomologists today are the type of men I have tried to describe, proud of their job, with a sincere love of their work and an honest desire to serve the profession and the public honestly and well, a fully sympathetic and respectful feeling for their co-workers in all fields of entomology, and a firm belief in the dignity of the work they are doing.
>
> Emphasis of these ideals, with recognition by our entomological teachers of the essential values and scientific integrity of commercial entomological work that it is entirely possible to attain, and a training of coming workers in these principles, along with a thorough grounding in the fundamental fields of knowledge that will fit the right kind of men to do effective work, should go a long way toward a further elevation of this particular branch of the profession into a position of respect and honor among all entomologists.

TEACHING AND TRAINING IN THE FIELD OF ENTOMOLOGY

CARL J. DRAKE, *Iowa State College, Ames*

This article was written upon request and for a purpose. The purpose is to help guide undergraduate and graduate students to a more adequate understanding of the scope of entomology and its objectives. It was with considerable hesitancy and diffidence that the writer accepted the invitation to prepare an address on teaching and training in entomology. It is hoped that the remarks will not leave the students standing suspended in a strange world that belongs neither to the past nor the future trend of entomology. Entomology is a relatively new and growing sci-

ence, and opportunities heretofore unknown are to open tomorrow for the properly trained and highly qualified students of today.

The interest in entomology has been steadily growing within the past three decades. This interest has been stimulated greatly by the outstanding work of many members of these two societies—The Entomological Society of America and the American Association of Economic Entomologists.

It is a well-known fact that no science can endure and continue to grow unless it is supported by public opinion. So long as entomology continues to form an important and integral part of the economy, health and recreation programs of agriculture and industry of the community, the state and the nation, it is not difficult to make predictions regarding the future trend and opportunity in the field. For this purpose every effort should be made to help the public bridge the gap between theory and practice. The labors and writings of many members of these two societies have done much towards bringing applied entomology within the grasp of the laymen and thus creating a proper atmosphere and an appreciation of the work. This leads to an understanding of needs for future activity and needs for financial support of entomology. To impart interest and enthusiasm and to secure the confidence and support of others, it is first necessary to have these traits oneself.

All vital teaching and training in any field of science—and entomology is no exception—requires constant change for advancement and progress, and a profession based upon training which fails to utilize fully new methods and new discoveries in allied and different fields of theoretical and applied sciences soon becomes atrophied. Zoology, physiology, chemistry, physics, botany, genetics, ecology and other sciences have contributed many facts which form a vital part of the present basic principles of entomology. Thus, the student of entomology must go to such scientific sources not only for certain facts relevant to his chosen field but also to learn that which all science has in common, namely, scientific method. Nobody is so well read and versed in entomology that he cannot learn much by contrasting and harmonizing the factual material, general conception and experimental technique and method with other fields of science.

The phrase "experimental method" in its broadest sense refers to a mental approach to an unsolved problem by the trial-venture method. Actual experiment followed by deductive reasoning is generally used in both the biological and physical sciences. In going from the implicit to the explicit, mathematical calculations often become more deeply involved in the physical sciences. Conversely, as the complexity of the system increases in the biological sciences, the difficulties encountered in isolating one set of conditions for experimental observation without serious complication from other phenomena, increase. In such cases the "experimental method" refers to the mental attitude towards the conclusion. The experimenter concludes that the system under a certain definite set of conditions will respond in a definite manner subject to a certain degree of biological variation. When the experimental method is referred to the reactions, the social life and the behavior of insects, the

observer records the natural phenomena in conjunction with the concurrent physical condition and from frequency of the repetition of the same phenomenon in conjunction with the identical biophysicochemical condition, establishes the correlation. If the "frequency of repetition" is inadequate in behavior and reaction studies, then purely deductive reason is employed.

As pointed out elsewhere in this article, entomology is being attacked from a variety of angles with the physiological point of view playing an increasingly important part. The employment of the experimental method makes the requirements for teaching and research equipment about the same as for the physical sciences. Insect physiology, insect toxicology, ecology and other types of experimental work use many of the same tools as chemistry, physics, physiology and medicine. This change in trend during the past several years has made it imperative to train students in the use, care and manipulation of expensive equipment. Much experimental work in both field and laboratory is now being done from a quantitative standpoint and then checked statistically.

Students majoring in entomology should have the interest, enthusiasm, ambition, natural aptitude, perseverence and mental and physical ability to be successful and happy in the work. Neither a college teacher nor a research leader can keep the students and younger members of the profession drinking from a clear-flowing spring of knowledge while he himself drinks from a dwindling puddle of contented stagnation. Research and extension workers as well as college teachers must guard against educational sterility and decay. The desire for self-improvement and constant growth-in-service should be a vital part of the philosophy of every man in all fields of science. Improvement in specific traits, qualities and abilities as well as in research and in other types of work are accomplished very slowly, unit by unit—only a few at a time—and never *in toto* as one pushes an electric switch on the wall to light a room.

For the capable and qualified student, entomology offers almost unlimited opportunity for original and fundamental research and applied work. Many members of these two societies have contributed scientific publications which will survive as long as English is read. In studying the works and lives of the unforgettable leaders the student should not overlook the rare insight and far-reaching foresight of the men who founded the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture and established teaching and research in entomology in the state institutions. The activities in the United States are very closely linked with the work in Canada, Mexico and other countries. To preserve and advance the standards, the ideals and the international spirit of the founders and pioneers in American entomology are heavy responsibilities that will test the best efforts of the present and future scholars, thinkers and men of vision in the profession. The entomology of today is chiefly and in the last analysis definitely the product of the past and present workers of the entire world. The members of these two societies and others are today in the process of making entomology which will soon be known as the entomology of yesterday, and at the same time they are laying the foundation and making the tradition for

the entomology of tomorrow and the more remote future. In other words, the present workers are living between the past and the future—rapidly making the entomology of yesterday, laying the foundation for tomorrow, and by far the most important of all, selecting, training and encouraging the young men and women for future activity.

Entomology is changing and advancing very rapidly as a profession. No one, of course, feels or even tries to make himself believe that the present system of teaching and training is leading either to the millennium or to the end of the world. The courses and the sequences of courses in the social sciences, humanities, mathematics, physical and biological sciences should be reasonably liberal, well balanced, flexible and adapted to the interests, mental needs and physical capacities of the students.

Social Science and Humanities

English.—From one to two years' work in English and speech is generally required during the freshman and sophomore years. In many colleges students are strongly advised to elect additional courses in the senior college. Grammar, composition, literature and public speaking are generally listed among the required courses. In the case of students who have not had the proper training in the grade and high schools and are more or less sadly deficient, two years is not sufficient time for them to acquire a basic knowledge and practice in grammar, punctuation, sentence structure, paragraphing, vocabulary, style and other essentials in English. The ability to express oneself clearly, accurately and forcibly, either orally or in writing, is a part of the fundamental requirements for a successful career in science. Much more should be done during the undergraduate years to help individual students to see themselves objectively and to correct deficiences in English and speech. In many colleges special efforts are now being made to emphasize practical writing and to correct faults in speech. Clinics of speech and clinics for speech deformities are now a part of the present educational system. This emphasis has done much to alter the attitude of the science student towards special courses in English composition and public speaking. The better student has a keen desire to acquire the necessary skill to organize and evaluate his research data and to express his discoveries clearly and coherently in both the written and spoken word. No one should be able to express one's findings and thoughts more clearly than the investigator.

Modern languages.—It is highly desirable to acquire the necessary or required knowledge of modern languages during the undergraduate years. In most graduate schools there is a very strong tendency to adhere strictly to the requirements of a reading knowledge of two foreign languages, namely, German and French. Sometimes special permission is given to substitute Spanish, Italian or some other language for French. High school students who show considerable ability and are much interested in science are often encouraged to begin a study of foreign language. Occasionally the language work is started in the grammar school. For graduate students who do not have the necessary knowledge of German and French, special classes are provided in most graduate schools.

Latin.—Many entomologists recommend that a knowledge of Latin

be acquired in high school or in the first two years of college. A reading knowledge of Latin is very desirable or quite essential in taxonomy and certain other fields of entomology.

Greek.—Very few students are advised or even attempt to become familiar with the Greek language. In a number of state colleges Greek is not listed in the college catalog. A knowledge of Greek is, however, of some value in any field of entomology.

Social sciences and economics.—Courses in history, government, economics and political sciences are required of science students in most colleges. A student, if so inclined, should be given opportunity to elect additional courses in these subjects; also courses in sociology, psychology and philosophy. Young men and women who are interested in college teaching should take courses in the psychology of learning and the principles and methods of college teaching and then work as assistants under the guidance of outstanding teachers in their major fields before accepting permanent teaching appointments. Part-time appointments under such titles as "teaching fellow" and "graduate assistant" are open to qualified students in most of the larger colleges and universities. To train and inspire young men and women as leaders in the fields of teaching and research is and always has been a challenge to the best teachers in science.

Mathematics and Physical Sciences

Mathematics.—College algebra, trigonometry and analytical geometry are required courses in most science curricula. Students primarily interested in insect physiology, insect toxicology and ecology will find a working knowledge of calculus very helpful. Biometric or statistical methods are now a part of the fundamental training in entomology. In certain fields many students find that two years of college mathematics are not sufficient to meet the requirements of the present day needs in entomology.

Physics.—A year's course in general physics should be required of most students in entomology. In such fields as insect physiology, insect toxicology and ecology, advanced courses in physics are often desirable. Biophysics, if developed by physicists with more training than they now possess in animal biology and general physiology, is destined to play a much more important role in the field of entomology.

Chemistry.—The present trend in science makes chemistry one of the most usable and essential tools in entomology. For several years the trend in entomology has been shifting towards the physiological point of view. This change has now developed considerable momentum and has had a salutary influence upon the direction of graduate training. As a result of this influence a much larger percentage of undergraduate students now include two or more years of chemistry in their courses of study. With the necessary training in mathematics, physics and biology, students are prepared to begin graduate study in entomology from a physiologic and ecologic point of view. General inorganic, organic, qualitative and quantitative analyses, and physiological chemistry are essential for the undergraduate major. Students primarily interested in

physiology, ecology and toxicology should take the more complete courses in organic chemistry and then plan to minor in chemistry as graduates. Biophysical, physical and colloidal chemistry are handy tools in insect physiology, toxicology and ecology. For students of biology the emphasis in chemistry should always be upon, not the industrial, but the biological phases. In some of the larger colleges and universities advanced courses in organic and physical chemistry are now offered for biological students with the major emphasis upon protoplasm and life processes. Perhaps there may be some truth in the statement that entomologists are rapidly becoming physiologists; physiologists, chemists; chemists, physicists; physicists, mathematicians; and mathematicians, philosophers. Whatever the trend or succession may be we are all very conscious of a change taking place in entomology.

Geology.—A course in general geology is of use in most fields of entomology. In insect ecology and certain applied fields, advanced courses in geology, paleontology and meteorology are very desirable.

Biological Sciences

As in most human endeavors, planning is the first and perhaps the basic ingredient for a successful career in entomology. The undergraduate training should be well planned and coordinated so as to articulate as a unit and thus give a broad, sound and workable knowledge of the fundamental principles of biology as a solid groundwork for future graduate study and specialization. Biology is very broad, all inclusive and contains many diverse and highly specialized fields of scientific work. Haphazard efforts, lack of planning, poor consultation and aimless selection of courses lead nowhere, greatly decrease the students' chances of success and, furthermore, waste much time, money and energy. Capable but poorly and improperly trained students must make up such deficiencies without credit during the graduate years. Lack of proper training may be the fault of the student, the instructor or both.

An examination of the credits of a graduate student will show whether he is equipped with a well-planned and coordinated training in biology and supporting sciences or whether he just drifted aimlessly into entomology without any particular interest or objectives. Students who as undergraduates have failed to show the ability, interest, personality, perseverance, skill, honesty and other necessary traits for a successful career in entomology should not be encouraged or permitted to continue their training as graduate students.

Advanced and graduate students are much interested in the different fields and opportunities in entomology. The development in entomology during the past few decades has made it impossible for any individual to excel in all the major lines of work. In outlining senior college and graduate studies the student and major professor (counselor) need to weigh with utmost care the value of the different courses in entomology, zoology and other subjects, recognizing that one cannot take all or even most of the courses in biology, mathematics and physical sciences as well as the needed work in English, history, foreign language and other subjects in the college catalog and at the same time leave sufficient mar-

gin for research, general reading and recreation. Health, another necessary factor in scientific work, should be not only protected but built up during the undergraduate and graduate years.

Applied entomology (such as insect pests of truck and garden crops, cereal and forage crops, stored foods, forest products, shade and forest trees, deciduous, small and citrus fruits, man, domestic and game animals, insect vectors of animal viruses and other animal diseases, insects as vectors of plant viruses and other plant diseases), insect physiology, insect toxicology, insect diseases and pathology, natural control of insects, insect ecology, taxonomy and apiculture are representative of the major fields. The development of strains of plants resistant to insect attack is a very promising field for development. Students who are primarily interested in entomological work should secure information regarding the different fields from outstanding teachers and research workers.

Zoology.—Animal biology or general zoology (invertebrate and vertebrate) is the starting point in all fields of zoology. For the undergraduate training no attempt is made here to separate entomology as a major from the field of zoology. Courses in embryology, parasitology, animal micro-technique, histology, physiology, elementary entomology, applied entomology and insect morphology are foundation courses which should be taken largely during the four years of undergraduate study. More emphasis is now being placed upon fundamental training in physiology—human, general and insect—for field and laboratory research work, insect biology, ecology, toxicology and applied entomology.

In the advanced undergraduate and graduate work, courses in zoology, physiology, entomology and other science subjects, every effort should be made to permit the student to develop and progress in his chosen field as rapidly as his mental ability and physical capacity will permit. Opportunity for creative thinking and original work should be provided and fostered early in the college life of highly interested, capable and superior students.

Training in zoology and entomology should form a broad foundation and furnish a degree of specialization in that field of entomology of primary interest to the student. In the senior college and graduate school there are no absolute or static standards, or perhaps one should say, there is no absolutely fixed curriculum which is needed in all or even in any single field of entomology. In the same field—not to mention widely separated fields—emphasis needs to be placed on different methods of attack and points of view. As stated elsewhere in this article, the graduate student needs to have definite objectives in mind and thus carefully plan and carry out advance and graduate study along the line of his major objectives.

Agriculture.—A general knowledge of the principles and practices of agriculture is of incalculable value in applied entomology. The control of insect pests of cereal and other field crops, truck and garden crops, orchards, forest and the like must fit into and become a part of the practices of the different fields in agriculture. Medical entomology or a study of the insects affecting the health of man, farm, game and other animals, involves many lines of work, such as human and veterinary medicine,

wildlife conservation and animal husbandry. Students specializing in this field can use to much advantage courses in parasitology, helminthology, protozoology, bacteriology, seriology, toxicology, pharmacology, animal husbandry and animal pathology. In fact one or two years of medicine would be a decided asset in the work.

Extra-curricular and other activities outside of the classroom form an essential part of the student's training and experience. The importance of visiting other institutions and the larger federal and state research laboratories, becoming acquainted with the more outstanding men in entomology and other sciences and knowing how and where to look up information in the library are at the present time receiving considerable emphasis in the colleges. Summer or temporary employment in entomology, even though the pay may not be very good, offers valuable experience for students.

Doctor's Dissertation

A dissertation (thesis) is required for the doctor's degree in all graduate colleges and may or may not be required for a master's degree. Most graduate colleges have published leaflets giving suggestions and requirements in thesis writing. A thesis embodies the organization of the experimental and research data written with a consideration of the existing literature. The doctoral thesis should represent a comprehensive contribution to the present day knowledge in entomology.

It is not within the province of this article to discuss the principles, theories and techniques of classroom and laboratory instruction. Growth in ability to think begins by thinking, to teach by teaching, to do research by doing research, and so on. Independent effort and accomplishment in research by undergraduate and graduate students soon becomes a motive force for further scientific endeavor. Teachers should not become puppeteers and try to train their students to behave and respond like puppets. One of the main objects of teaching and training is to develop an inquiring mind and a capacity for independent thinking and original work during the days when both body and mind are very plastic. Education is never finished and is a broadly continuous process of development throughout life. Neither is scientific knowledge full and complete, and there are very many profitable directions for present and future extension.

Teacher Responsibility to Students

Now to reverse the scene for a moment. Certain other questions of primary interest to both undergraduate and graduate students deserve more attention in the fields of teaching, extension and research than they have been given heretofore. What can and should the student of ability and desirable traits expect of the college teacher as a teacher? Of the college or university as a whole while a student? Of the federal and state workers as leaders after graduation? These questions and others are all such as to raise many problems worthy of careful study and long thought. A discussion of these questions would take us very far afield and is hardly within the scope of this paper. The questions, nevertheless, are of fundamental significance and should be studied by the more capable and

active leaders in entomology. As textbooks which are not revised and brought up to date soon become out of date, obsolete and eliminated from the schools, so too, ineffective teachers, research and extension workers and administrators soon become out of date and obsolete and then they, too, should be eliminated as humanely as possible from the very active and responsible positions in the educational and scientific worlds.

In conclusion, it should be stated that the personnel, equipment and other facilities of colleges and state and federal laboratories at the most simply offer the opportunity for training and experience. Under the most favorable educational condition and system it is, nevertheless, the student's problem to secure his own education and at the same time to train himself to get the utmost in life and thus secure as reward a reasonable amount of satisfaction and happiness.

SYMPOSIUM: ORCHARD SANITATION

Under the direction of J. J. DAVIS, *Lafayette, Indiana*

For many years, especially since the days of F. M. Webster, entomologists have recognized the importance, and in fact the necessity, of farm or cultural practices in the control of insects attacking cereal and forage crops. Indeed, many of the good practices now recommended by agronomists were instigated because of a need for insect control.

The increasing cost of insecticide controls, the insecticide residue problem, and the lack of adequate control in many cases by the use of insecticides, have led entomologists, and I believe also plant pathologists, to give more thought and attention to the value and utilization of supplementary controls, many or most of which are cultural.

In Indiana, and I dare say the same is true in many other states, we have emphasized the value of certain orchard practices to aid in the control of such pests as the curculio, codling moth and leafhopper. The same is true in the case of vegetable crop pests. May I cite a single example. Our records show that we seldom have a general outbreak of the onion maggot. Hardly a year passes that we do not have one or more outbreaks, but they are usually more or less isolated. Mr. George Gould's studies showed that this pest was abundant only in areas where cull or nonsalable onions had been left in the field or where piles of onion residues were left on the premises, these conditions offering excellent breeding places and sources of infestation the following season. And so we could go on with many other examples to illustrate the relation of farm practices to the abundance of this or that insect.

Not only are these good cultural practices of direct value, but in addition they are of great psychological value. The grower who adopts good practices and keeps his premises free from the conditions which favor insect or plant disease development is usually more thorough in his application of insecticides and fungicides and incidentally gets the best returns for his efforts.

It is hoped that the symposium to be presented this afternoon will not

only give each one here valuable information but that it will stimulate deeper research into the problem of cultural and sanitary practices as they relate to insect and plant disease control.

Furthermore, it is hoped that the exchange of ideas between horticulturists, plant pathologists and entomologists will materially aid in coordinating our efforts, because it must be obvious to everyone that greater and closer cooperation between these related sciences is one of the real needs of the present day.

MEASURES OTHER THAN SPRAYING FOR THE CONTROL OF ORCHARD INSECT PESTS

D. L. VAN DINE, *U. S. D. A., Bureau of Entomology and Plant Quarantine*

Certain orchard operations, other than applications of insecticides, that influence the control of insect pests are recognized as a part of good orchard management. The object of this paper is to bring out for discussion certain phases of this problem, rather than to present any new methods of insect repression. The fact is, we could present little in terms of new methods that might be written into a control program, but under present conditions there is need for a shift in emphasis in our investigations on orchard insects and their control.

In considering measures other than spraying there is no intention of opposing one method of control against another. Over a long period of years spraying has gained its place, and will hold it, in orchard practice for both insects and diseases. We have gone far since the days of the barrel fitted with the hand pump and the one insecticide, Paris green, for chewing insects. The problems of spray materials, spraying equipment, spray applications, timing of sprays, compatibility of sprays with fungicides, effect of sprays on the plant and the fruit, and spray calendars to meet local conditions have engaged our attention in great detail, and a fund of valuable information is a matter of record. We should consider at this time not so much our stock of information as the direction in which it is leading us and determine whether under present conditions we have a balanced program of control, whether measures other than spraying are receiving the emphasis due them, whether indeed we have not become somewhat "spray-minded." In any shift of emphasis we must keep a balanced program of control strictly in mind, avoiding undue stress of any particular method.

Emphasis on any one orchard insect pest may result in a like situation. One of the lessons we have learned from our work on the codling moth is the danger of considering this insect apart from the orchard insect pests as a whole. All insect control problems are complex, and we can no more control one insect in an orchard to the exclusion of all others than we can bring control to a final issue by one means of attack. In his presidential address before this Association last year, Doctor Philips dealt with the complexities of economic entomology and found an example in the

codling moth situation as it now exists. Keeping to the codling moth, which stimulated this discussion here today, as an example, we recognize this insect as the outstanding apple pest, presenting a problem that deserves every effort that can be directed toward its control, but we cannot say that the injury sustained from the codling moth exceeds that of all other apple insects combined. In our experimental field set-ups for the codling moth we found, in fact, that we were unable to exclude consideration, not only of other insects, but of diseases as well. Despite any ideas we may have to the contrary, apple scab, leafhoppers and mites, the flea weevil, the apple maggot, the aphids and the scales write themselves into our program without invitation. In our orchard-insect control program, then, we cannot center our efforts on any one measure, nor can we divorce the problem of one insect from the larger problem of all the insects and diseases that exist in the orchard. There is one fundamental fact to consider in the codling moth problem, and that is that the control effort centers around the insect; but such effort must be coordinated and directed toward control to meet present conditions of production, including market standards and requirements in the interest of public health.

In dealing with the codling moth we have been inclined to think of only the insect and its control, rather than the problem which the spray residue situation presents. If the prevention of worm entrance to apples is the only problem then the codling moth becomes just another apple insect. We must recognize that the problem of a residue that may be objectionable if it is not removed before the fruit enters the market has served to focus attention on the codling moth.

The problem of residues on fruits has intensified the effort to develop or discover insecticides that do not offer the serious objections raised against the more common inorganic chemicals. It has also caused us to recognize the desirability of utilizing any control measure that does not involve the use of insecticides.

The normal level of codling moth population varies greatly in different sections of the country. The reasons for this are largely climatic. However, variations in moth population occur in the same section, and even in different parts of the same locality. Under a low level of infestation, control is gained by an abbreviated spray schedule, and it follows that the residue at harvest time is less. Accordingly, if a lower level of moth population can be insured, the spray residue problem is greatly simplified. Certainly we have the evidence that insecticides, including lead arsenate, have in many areas failed to control high infestations, irrespective of the conditions that brought about the unusual moth abundance. When infestations are high we are confronted with the limits not only of the efficiency of insecticides but also of the tolerance of the trees to the insecticides. Furthermore, if infestations can be reduced to a comparatively low level we may maintain control by not allowing those conditions to persist which might contribute to the building up of high infestations.

The use of non-spraying methods against the codling moth, of the so-called "supplementary measures," is much older than the use of the in-

secticides it is now suggested that they supplement. In 1838 Westwood (*12*) suggested the "gathering up of the worm-eaten apples immediately after their fall, and before the enclosed caterpillar has had time to make its escape." Burrelle, according to Simpson (*9*), was apparently the first one to suggest the well-known banding method. This was in 1840. Burrelle (*1*) suggested winding something around the tree, or placing a cloth in the crotch and then destroying in a hot oven the larvae that are caught. Harris (*5*) in 1842, in addition to banding, advised that in "carefully scraping off the loose and rugged bark of the trees, in the spring, many chrysalids will be destroyed." Riley, in his first Missouri report (*8*), 1869, discussed the "hay-band" of Trimble and its use, and advised that "the trunk of the tree should be kept free of old rough bark so as to give the worms no other place of shelter" and that "the ground itself should be kept clean from weeds and rubbish."

While we have Trimble in mind, let us consider briefly the market standards of fruit today and, from an observation he made, draw a comparison between the present and the past. On September 13, 1864, he attended the American Pomological Convention at Rochester, N. Y., and comments as follows on the condition of the exhibits of fruit (*11*):

> By one who has not cultivated a propensity to seek out the blemishes in the fruits caused by the insect enemies, most of those on exhibition here would have been pronounced fine; but upon a close examination by eyes like mine, where the focus is fixed on defects, of the hundreds of plates, not one in twenty contained fruits that were all sound. Three fourths had curculio marks, and one half had been more or less tampered with by the apple moth.
>
> I was speaking on this subject to a company of delegates from different sections of country, when one from Wayne Co., N. Y., pointed to some of his on a table near us, as all sound. This challenged an examination, when more than half were found specked by one or the other, or both of these enemies.
>
> If these specimen fruits were so defective, showed such evidence of the enemies, we may infer that those left at home, from which these were selected, were much worse; showing unmistakably that the time is rapidly coming when something must be done, or all will perish when there is a thin crop to begin with, and most that are left of the plentiful crops will be seriously blemished.

Ten years after Riley recommended the use of clean-up methods, and forty-one years after Westwood advised picking up drops before the worms had had time to escape, Paris green was applied to apple trees in western New York early in the season for the cankerworm, and it was noted that the sprayed trees were free from codling moth whereas the unsprayed trees were badly infested (Woodward, *13*). In the spring of 1880, Cook (*3*) made two applications of London purple to apple trees for the codling moth, and the control was reported to be perfect. It is interesting to note that the possible danger of using an arsenical on fruit

was also considered at that time. Cook applied the spray on May 25 and on June 20, using 1 pound of London purple to 100 gallons of water, and he reported that 100 blossom ends cut from the sprayed trees on August 19 showed no trace of arsenic. L. O. Howard, after reviewing the codling moth situation in 1887 (*6*), mentions the destruction of windfalls; picking wormy fruit from the trees; prevention of adult moths issuing from storerooms, storehouses or barns; banding; and the use of arsenical mixtures, as being "of considerable practical utility." Howard states, "In a badly infested orchard all could be used to good advantage."

In 1903 Simpson (*9*) wrote that the codling moth should be considered from the time the orchard is planted, and he divided the methods of control into two classes, preventive measures and remedial measures. Simpson pointed out a serious error made by many fruit growers in reasoning that the first crop is not worth saving and allowing the insect to infest most of it, with the result that the following year the insect is abundant and serious losses occur, whereas if the apples had been destroyed by being picked and buried, or if bands had been used, much of the second year's loss could have been prevented. This applies equally to trees bearing a few apples in off years, and to crops partially destroyed by a freeze when the fruit is reduced to a minimum. Under such conditions the grower is not able to produce a crop of fruit, but it does rest with him whether he produces a crop of worms or not. As preventive measures Simpson discussed thinning; picking up drops; disposing of culls as quickly as possible for cider or other purposes; making storage places moth-tight and destroying any moths present by fumigation or screening; giving proper dressing to the stubs of branches that have been cut away, where worms spin their cocoons and hibernate; pruning trees in old orchards so that spraying solutions will have easy access to the foliage and the fruit; filling holes in trunks and branches with cement, plaster or clay so that larvae will be unable to enter; and rendering unsuitable all places where larvae might find shelter. Simpson considered spraying and banding under remedial measures. In conclusion he said, "The preventive measures are fully as important in controlling this insect as the remedial measures."

We can well afford to give considerable attention to measures other than spraying for the control of orchard insects. Our best chance of improving our control program is by bringing our research program into better balance. There is need for more exact information on the supplementary measures we are now recommending, not only to obtain basic figures on these operations but also to determine the possibility of increasing their effectiveness. The study of measures that have not reached the development necessary for their practical application, such as the use of baits, lights, repellents and parasites, should be continued. The welfare of parasites is of particular importance. We know that many of our direct measures of control seriously handicap these natural agencies, but we do not know the manipulation necessary to avoid this interference.

The research program on the codling moth should include field experimentation on banding, thinning, and picking up drops, clean-up work to

destroy the places where the worms may find shelter, and screening of packing sheds. The plum curculio offers another example for experimentation in determining the value of picking up and destroying early drops, jarring and cultivation. In vineyard work the overwintering form of the grape berry moth offers a vulnerable point of attack. Many other examples might be given of control measures that, if put in practice, would permit the fruit grower to ease up on his spray program.

During the season of 1934 experiments were conducted on the value of clean-up methods in reducing worm injury in apples. The results were reported by Steiner and Ackerman (*10*). The clean-up work in combination with banding reduced the worm injury more than 40 per cent the first season. A further report on this test of orchard sanitation for control of the codling moth has been made at this meeting. An important feature of the experiments was the use of the chemically treated bands developed by the federal Bureau of Entomology and Plant Quarantine in cooperation with numerous state agencies. This type of band has the practical advantage of eliminating the need for hand labor during the growing season, when available competent orchard labor is occupied with other activities. This factor and the urgent need for control measures other than spraying have caused chemically treated bands to come into extensive use.

Newcomer (*7*), in referring to banding under commercial orchard conditions in the Pacific northwest, states that chemically treated bands placed on trees that have been thoroughly scraped may destroy 75 per cent of the worms leaving the fruit, at a cost of less than 10 cents per tree. He says:

> In one test at Yakima, covering three seasons, a block of banded trees was less than two thirds as wormy at the end of the test as a similar block, not banded. Many growers are already convinced of the value of this method. In 1933, about 33 per cent of the orchards in the vicinity of Yakima and Wenatchee were banded, and in 1934 about 37 per cent were banded. Of 700 orchards examined in 1934, only 6 showed evidence of having been banded in 1933 and not in 1934.

Childs (*2*) tells about a method for treating orchard boxes with steam to destroy the worms which often find shelter in the boxes in large numbers. The equipment for treating the boxes was developed by the apple grower's association of Hood River, Ore. It is believed that this treatment has greatly aided the control of the codling moth in the Hood River area. Commenting on the spread of the insect by boxes, Childs says:

> Without question, dissemination of the codling moth readily occurs where boxes are circulated indiscriminately among fruit growers. Often times boxes are stacked up in open sheds or brought from the packing house and stacked immediately adjacent or in the apple orchard. Where untreated boxes are so placed moths leave them and readily find the fruit with the result that control problems are made just that much more difficult. Where a quantity of boxes are to be handled and steam is

available, this treatment may be employed without incurring any great cash outlay.

The production of moths in a packing house has recently been discussed by Davis (4). He reports the screening of a three-story packing house, 72 by 72 feet, with cloth. The cloth had served its purpose for three years. In 1934, prior to July 27, a total of 236,300 moths were captured and destroyed. The maximum catch for a single day was 15,579 moths. An estimated additional 30,000 moths were found when the cloth screening was removed. Since 45,000 bushels of apples were handled in the packing house in 1934, about 5 moths were captured for every bushel of apples handled. Davis mentions that Slingerland (1898) found hundreds of cocoons in a single barrel of stored apples. According to Davis' records, 17 moths were captured per square foot of floor space in the packing house. On the basis of an annual expenditure of $23, it cost one cent to destroy 115 moths. Is it better to kill these moths before they reach the orchard than to fight the resulting worms afterwards in the orchard?

In so far as high infestations of the codling moth or other orchard insect pests are caused by neglect of sanitary measures and other measures that do not involve spraying, we believe the high populations to have been built up over a period of years, reaching an acute stage in the older orchards. If such is the case, it will take a number of years to realize the full benefit of clean-up practices. The cost of such measures should not be charged to production costs for the year they are initiated, but rather distributed over a period of years in the nature of an investment, since the maintenance costs will be far less than the initial expenses. To meet present conditions, we must place more emphasis on the measures for orchard insect control that do not involve spraying, continue the search for more desirable spray materials, closely coordinate our work as entomologists with all phases of the problem that concern other fields of research, and pay more attention to the technique of the spraying operation.

If we bring our research program for control into better balance and find that an abbreviated spray schedule is possible, we will have less of a residue problem at harvest time. Furthermore, the resulting economy in the spraying operation will take care of the cost of maintaining an orchard under conditions of good sanitation as a necessary part of a balanced program for controlling orchard insects.

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SOME PROBLEMS AND PRINCIPLES OF ORCHARD DISEASE CONTROL

WITH SPECIAL REFERENCE TO SANITATION AND RELATED MEASURES

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When I was invited to participate in this symposium I accepted gladly, because it promised to serve two purposes in which I have much interest. First, it would bring entomologists, plant pathologists and horticulturists together for joint consideration of their common problems, and second it would encourage a critical reëxamination of the principles that underly our programs of orchard pest control. However when I came to the more sober task of preparing a paper on my assigned subject of "Orchard disease sanitation problems," I began to wonder whether I had not permitted enthusiasm to get the better of discretion. How could one approach the problems of orchard disease sanitation except in their relation to those of epidemiology and of other phases of the control program? Again, what measures are properly considered in the category of sanitation? Is the concept, indeed, the same for entomologist and plant pathologist? But surely, I thought, this gathering will not be interested in either the details of our respective scientific jargons or any artificial restriction of subject. Rather, it will be concerned with a canvass of major possibilities for the improvement of our programs for orchard pest control. Accordingly, I have taken the liberty of somewhat broadening the scope of my subject, and have undertaken to approach it from the point of view of what I conceive to be some of the more important problems and principles of orchard disease control, with special reference to sanitation and other measures designed to lower the survival level of pathogens.

Dominance of the principle of protection.—For the fifty years that have elapsed since Millardet's discovery of Bordeaux mixture, spraying (including dusting) with protectant fungicides has been the dominant measure for orchard disease control; and in the discussion which follows

I wish in no wise to detract from the splendid achievements of protectant spraying. The story of its successes is one of the most thrilling in the history of plant disease control; and it is no fault of this method that in our satisfaction with its remarkable accomplishments we have sometimes been slow to recognize that it has serious limitations, or that we have failed to seek as actively as we might for measures to supplement it. I doubt that we have reached the limits of improvement in the materials used as protectant fungicides, and am very confident that we have not nearly come to the stage of diminishing returns in studies of either the suitable relation of protectant fungicidal programs to the epidemiology of the diseases concerned or their effects on the treated plants, especially cumulative effects. I suggest therefore that in seeking to improve our programs for orchard disease control, more rather than less attention should be given to some aspects of protectant spraying.

Some limitations of protectant spraying.—Having briefly pointed to the accomplishments of protectant spraying, let us consider some of its limitations. I think that the most fundamental one is that it commonly permits the pathogen to survive at a dangerously high quantitative level. Thus, while the sprayed plant may be very satisfactorily protected throughout the season so far as concerns its growth and the production of a clean crop, nevertheless a sufficient amount of infection usually occurs to permit the development of an abundant, annually recurring, primary inoculum. Consequently year after year orchardists are likely to pick up the burden of disease control in the spring in no better position than in the season before. Furthermore, for many of our fruit diseases the protectant spray programs are costly, cumbersome, potentially injurious to the host plant, and uncertain of satisfactory control under adverse conditions. So long as these disadvantages exist they will constitute a challenge to the skill of our profession, and diseases will continue to exact a heavy toll from growers and consumers of fruit.

In what directions shall we seek improvements?—We have noted some of the weaknesses of disease control programs that are based too exclusively on the principle of *protection* from pathogens that are permitted to survive at dangerously high quantitative levels. How may such programs be improved? Three major possibilities seem to be: (1) the development of measures based on the principle of *eradication* and designed to reduce pathogens to such low survival levels that they can be surely and economically controlled by complementary procedures, (2) improvements in protectant spraying, and (3) increased use of the principle of *immunization* through the development of resistant varieties. The first of these will be the chief topic of our further discussion.

Present status of eradicant measures.—How is the principle of eradication applied to the control of orchard diseases? Let us consider some current types of eradicant measures, with examples of their adaptation.

1. *Removal or destruction of diseased plants.*—Examples: peach yellows and rosette, little peach, phony peach and citrus canker (*Phytomonas citri* (Hasse) Bergey *et al.*). This method has been used with remarkable success against the comparatively few orchard diseases to which it is adapted. Its success in the eradication of such a highly infectious and

drastic disease as citrus canker, after the malady was well established in a new and congenial region of intensive culture of the affected plants, is an achievement unparalleled in the history of plant disease control. The notable success of the principle of eradication here and in the case of the virus diseases of peach should encourage efforts to extend its use through suitably adapted procedures.

2. *Excision of diseased parts.*—Examples: fire blight of pomaceous fruits (*Erwinia amylovora* (Burr.) Bergey *et al.*) and numerous canker diseases. This method has been widely used, with valuable results. In general, however, it is best regarded as a complementary, rather than a sole, measure of control; and its use may well illustrate the desirability of developing a control program of related procedures in contrast with reliance upon a single measure.

3. *Removal of alternate or complementary hosts.*—Example: apple rust (*Gymnosporangium juniperi-virginianae* Schw.). This method is obviously very effective in situations where it can feasibly be used. It is, however, applicable to only a few orchard diseases.

4. *Removal of "weed" hosts.*—Example: fire blight of pomaceous fruits. An illustration may be drawn from experience in New Zealand, where it was found necessary to remove hedges of susceptible hawthorn which were adjacent to orchards. The adaptation of this method to orchard problems is rather limited.

5. *Destruction or disposal of diseased parts or refuse which may harbor the pathogen.*—Examples: brown rot of stone fruits (*Sclerotinia fructicola* (Wint.) Rehm), bitter rot of apple (*Glomerella cingulata* (Stoneman) S. & von S.), and many other diseases. This measure, which most plant pathologists would rather loosely designate as sanitation, is the most widely used eradicant procedure for orchard disease control. It has given valuable results against a wide variety of diseases and seems to merit further careful attention. Because of the nature of the procedures and effects concerned it peculiarly deserves the combined attention of pathologists, entomologists and horticulturists.

6. *Spraying with eradicant fungicides.*—Example: peach leaf curl (*Taphrina deformans* (Berk.) Tul.). This comparatively neglected method is used with notable success against peach leaf curl, a disease peculiarly vulnerable to it on account of the unusually exposed position of the primary inoculum and the failure of the pathogen to develop a true secondary inoculum. Possibilities for increased adaptation of eradicant spraying to orchard disease control will be given further consideration later.

Since the chief purpose of measures of eradication is to reduce the survival level of the pathogen, it should be borne in mind that control methods based on the principles of protection and immunization also may make important contributions to this end. Protectant spraying, for example, commonly effects a substantial lowering of the survival level of the pathogen, and this may be reflected in cumulative control over a period of years. Such indirect advantages from measures based on protection and immunization should be utilized where feasible. However, by themselves they usually fall far short of the desired effects.

The need for basic research.—The chief current methods for applying the principle of eradication to orchard fruit disease control are before us, and it would be a very easy and pleasant task to spend my remaining time in reviewing some of the valuable individual contributions to this line of progress. However, I think it will be much more useful to seek to turn our eyes to the future, and to think rather of the things that have not been done. With all appreciation of the valuable contributions that have been made to the application of the principle of eradication to orchard disease problems, let us ask why this vitally important principle still plays such a comparatively minor rôle in the control programs now in *actual use* against so many of our destructive fruit diseases. I venture to suggest two major reasons: (1) that we lack a sufficient understanding of the epidemiology of most orchard diseases and of the *actual effects* of eradicant procedures in relation to their control, and (2) that many recommended eradicant measures are either impractical of execution or so inefficient as to be of questionable utility. Let us remember that sanitary procedures were recommended for orchard disease control long before the discovery of the rôle of pathogens in the causation of infectious diseases. They were empirical in their beginning, and they have remained so to an unfortunate degree. Can we rightly expect eradicant measures to play their appropriate rôle in orchard disease control until they are securely based on an adequate foundation of soundly established fact? This brings us to what I conceive to be the most important problem that confronts us in our search for means of improving methods of orchard disease control. I refer to the need for a much sounder foundation of knowledge of the detailed phenomena and basic principles of disease development and control than that on which most of our current programs rest. Only in the light of such knowledge can we either clearly define our control problems or reliably evaluate the results of the measures used.

Apple scab control as an illustrative problem.—Let us now seek to illustrate and develop the point of view of this discussion by considering some of the problems and principles of control of a representative disease, apple scab. Since time is pressing and the chief purpose is to invite attention to things that have not been done, I trust that I may be pardoned for drawing quite freely upon our Wisconsin experience[1] without attempting the impossible task of a balanced presentation of our studies and consideration of the valuable contributions of other investigators. It will however be necessary briefly to review the progress of certain phases of the work, in order to show illustrative sequences of development and to define certain problems for future study.

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Apple scab, caused by the parasitic fungus *Venturia inaequalis* (Cke.) Wint., is very familiar to most of us as the most wide-spread and important disease of deciduous orchard fruits. It is to the plant pathologist what the codling moth problem is to the entomologist. The combined control of scab and codling moth comprises the most important problem in combating the pests of deciduous orchards. Apple scab and its control have been intensively studied for nearly fifty years, and a valuable literature of many hundreds of papers has accumulated. Great progress has been made in the improvement of control methods. Nevertheless scab continues to take its toll of many millions of dollars annually. The cost of the spraying alone is great, and failure to control the disease under conditions that permit its severe occurrence is an all too common experience. Why do spraying methods which are so successful in controlling light or moderate outbreaks of scab often fail to control the more severe epidemic outbreaks, and how may the scab control program be improved? It was in the hope of contributing to the answers of these questions that our studies at Wisconsin were begun.

Experimental approach.—Experimental approach to the problem was based on two fundamental concepts: (1) that the disease results from the activities and interrelationships of two plastic organisms, each variable under the influences of heredity and environment, and (2) that the consequences of control measures vary with complex and changing conditions. It was sought to devise methods by which the progressive development of the disease and the action of control measures might be traced with a sufficient degree of accuracy to permit at least an approximate analysis of major factors that determine the development of epidemics and the effectiveness of the control measures used.

The complexity of the problem set sharp limitations on the refinement with which such an analysis could feasibly be made. However it was obvious that a study of isolated relationships or too fragmentary phases of developmental cycles or sequences would not suffice. Accordingly two correlated major lines of work were initiated: (1) field studies of the progressive development of the disease and of the effects of control measures in relation to the play of the natural environment, and (2) experiments on the development and prevention of the disease under partly controlled environmental conditions in laboratory and greenhouse. In the field it was sought to record certain important aspects of the seasonal development of host, pathogen, disease, and the application and effectiveness of control measures in relation to suitable meteorological records. In the laboratory and greenhouse it was sought, with the greater flexibility of experimentation that is possible under controlled conditions, to work out problems defined by the field studies and to build up a body of data on disease development and control in relation to environment that would facilitate the interpretation of field phenomena. Each of these lines of work served as a check against the results of the other.

The ascosporic inoculum in relation to scab development and control.—Without going into the details of the methods that were employed, let us now consider certain phases of the work which bear directly upon our theme of orchard sanitation. When these studies began nearly 20 years

ago it was the accepted practice in the most widely used spray programs against apple scab to make the first application at or shortly before the open-cluster stage of blossom development. It was in fact the signal failure of such programs under Wisconsin conditions that occasioned the initiation of our work. One of the first problems therefore was concerned with the rôle of the ascosporic inoculum and early-season infection in relation to epidemiology and control. When, in what quantity, on what plant parts, and under what environmental conditions does ascosporic infection occur? Do ascospores comprise the only important primary inoculum under Wisconsin conditions? Should the spray program be designed to prevent ascosporic infection, or may this be tolerated and the disease more economically controlled by directing the defense against the conidial inoculum?

These questions were fairly adequately answered by the studies that have been mentioned. Ascospores are usually matured in Wisconsin before the susceptible host parts are exposed. They are liberated, when the leaves are sufficiently wet, at all orchard temperatures above 0° Centigrade. They occur in concentrations as high as 200 to 300 per cubic foot in orchard air. They are capable of infecting young leaf, blossom or fruit parts at very low spring temperatures. The leaf and sepal tips, which are the first tissues to be exposed in the opening cluster buds, are susceptible to infection. Danger of infection of both leaf and blossom parts, therefore, commonly begins early in the green-tip stage of cluster bud expansion.

A detailed study of the consequences of sepal infection was of special importance in analysis of problems of scab control. Conidia are produced abundantly on the infected sepals. It was found that in the absence of meteoric water wind is not as previously supposed an important agent of dissemination of conidia of this fungus. They are disseminated chiefly in meteoric water, moving under the influence of wind and gravitation. From a peculiarly strategic position on the sepals they are carried in great abundance to the cheek of the same fruit. The sepal-infected young fruits therefore constitute a special class in relation to disease development and control. They scab far more severely than fruits without sepal infection; and close examination into the results of certain unsuccessful spray programs has shown that non-sepal-infected fruit was adequately protected, the failure being confined to the sepal-infected class. Suitable adjustments of the time and number of early treatments have greatly improved the effectiveness of the spray program.

The work that I have mentioned and other studies seem to point to the conclusions: (1) that the ascosporic inoculum and its quantitative level are of primary importance in relation to the epidemiology and control of apple scab, and (2) that it is highly important to orient our present type of spray program against ascosporic infection.

Why the recurrent ascosporic inoculum?—While certain questions are being answered, others are raised. Why do we have this troublesome annually recurrent ascosporic inoculum?

The studies that we have cited have shown clearly that the problem of control of scab on the fruit is far different from that of its control on

the foliage, and that our current protectant fungicidal programs are adapted primarily for control of the fruit phase of the disease. Since the blossoms are all expanded in a relatively short time it is usually feasible to keep them and the developing fruits adequately protected by fungicidal treatments. However, new leaves are exposed over a much longer period. They may expand unprotected surface between spray treatments of any feasible frequency. No protectant fungicidal program has been found which will safeguard the foliage from scab infection effectively enough under moderately severe conditions to prevent the development of a menacing ascosporic inoculum. The foliage infection that develops is often so inconspicuous that even an expert will fail to note its presence. Much of it may not be macroscopically visible even at the time of leaf fall. Nevertheless it is there, even in the best sprayed orchards.

Potentialities of eradicant fungicides for limitation of primary inocula.—What are the possibilities of improving scab control by efficient limitation of the ascosporic inoculum? Disposal of the fallen leaves by such methods as raking and burning was recommended long before it was known that the scab fungus overwinters in the fallen leaves. Various recommendations for the application of sanitary measures for scab control are still made but there is surprisingly little experimental evidence on which to base a judgment of their efficiency. Furthermore, some of them seem to be impractical under conditions of commercial orcharding. The result is that at present sanitary measures play a very minor rôle in the control of this important disease. It appears therefore that improvement in methods will be necessary if satisfactory limitation of the primary inoculum is to be accomplished. For about 10 years we have sought at Wisconsin to develop a satisfactory method for this purpose. Though our objective has not yet been attained a brief report of progress seems pertinent.

The period after harvest and before substantial leaf fall was regarded as a potentially vulnerable period in the life history of the scab fungus, and one in which the host would tolerate a comparatively drastic fungicidal treatment. It was sought therefore to develop a spray treatment which might be safely applied at this time and yet be sufficiently drastic to effect a satisfactory limitation of the production of ascospores. Experiments with the more commonly used spray materials revealed none satisfactory for the purpose. Preliminary experiments with a wide variety of chemicals showed that certain arsenical preparations, especially certain arsenites, have high fungicidal values, and that mixtures of copper sulfate, lime and certain arsenites in water have much promise as eradicant fungicides. Hundreds of small-scale fall spraying experiments with such materials over a period of years have shown many formulae to be highly effective in preventing or sharply limiting the production of ascospores of the scab fungus in the treated leaves. Some preparations have caused serious injury to the sprayed plants, while others have not. The combination of sufficient fungicidal effectiveness with freedom from danger of objectionable host injury is the most difficult aspect of the problem. Several formulae appear to be on the threshold of meeting both requirements; but much more experimentation will be necessary before

conclusions can be reached as to whether or not these treatments should have a place in the scab control program. Not only must they satisfactorily meet the requirements of safety and of efficiency in limiting the ascosporic inoculum, but it must be shown experimentally in actual orchard practice that such limitation of the ascosporic inoculum has effects on the epidemiology and control of the disease which will justify use of the measures concerned.

Only a small beginning has been made in experimentation on the effects of these fall treatments with eradicant fungicides in relation to the epidemiology and control of scab. Such work has had to await a sufficient narrowing of the problem and the availability of experimental facilities. In 1934 an experiment was started on two plantings of young Wealthy and Northwestern Greening trees. Plot 1 received a copper-lime-arsenite spray in 1934, and was nearly free from perithecia of the scab fungus in 1935. Plot 2, about 100 yards away, received no fall spray, and developed a comparatively light ascosporic inoculum. Neither plot was sprayed in 1935. On the basis of counts, and taking the results of plot 2 as 100 per cent, the following percentage reductions in amount of scab were indicated for plot 1: May 31 (petal fall), Wealthy leaves 96; June 24, Wealthy fruit 91; June 29, Wealthy leaves 89, Northwestern Greening leaves 96. On Sept. 4, 89 per cent of Wealthy fruit of plot 1 was scab free. Plot 2 bore insufficient fruit for counts. Climatic conditions for scab development in 1935 were good.

An unusual opportunity to gain evidence concerning the effects of a sharply reduced ascosporic inoculum on the epidemiology and control of scab arose in connection with studies at Gays Mills, Wis. The phenomenally dry season of 1934 reduced the scab fungus to such a low survival level that the ascosporic inoculum in 1935 was the sparsest ever encountered under conditions of commercial orchard practice in our Wisconsin studies. In some plantings of susceptible varieties it was difficult to find perithecia. There were four well distributed rain periods in the interval between the green-tip and open-cluster stages of bud development, and the period for six weeks after petal fall was exceptionally favorable for scab infection. With a normal ascosporic inoculum the expectation would have been for one of the most difficultly controllable scab epidemics in our experience. Various reduced schedules of summer sprays were tried. A lime sulfur program beginning with the open-cluster spray gave excellent results on a block of McIntosh where the ascosporic inoculum was extremely sparse. Even a program beginning at petal fall gave only 16 per cent of scabbed fruits at harvest.

The results of the two lines of work just reported, while limited in extent, are in accord with much other experimental evidence which indicates that sufficient reduction in the quantity of the ascosporic inoculum should greatly facilitate scab control.

The promising results with eradicant copper-lime-arsenite sprays against apple scab encouraged some preliminary studies of their potentialities for reducing the primary inocula for other plant diseases. Spraying leaves in the fall prevented or sharply limited ascospore production by the pear scab and cherry leaf spot pathogens (*Venturia pyrina*

Aderh. and *Coccomyces hiemalis* Higgins). Late dormant spraying killed the perithecia of the cherry black knot and raspberry spur blight fungi (*Dibotryon morbosum* (Schw.) T. & S. and *Mycosphaerella rubina* (Pk.) Jacz.), and very sharply limited the production of conidia on persistent plum fruits which had been mummified by brown rot the season before. These and other experiments have demonstrated a high effectiveness of these materials against fruiting structures at or very near permeable surfaces of diseased tissues. Since either the fruiting structures of fungus pathogens are produced at or near the surface or else the spores must come to the surface for liberation, potential vulnerability of many plant pathogens to attack by surface applications of eradicant fungicides is indicated.

The toxicities of various preparations of copper sulfate, lime and certain arsenites have been studied by means of a pure culture technique. Certain calcium arsenites, each used alone, equaled or exceeded copper sulfate in toxicity. The toxicity of copper sulfate-lime-arsenite preparations equaled or exceeded the additive toxicity of the copper sulfate and the arsenites used in them. Such preparations showed a high toxicity to all of 10 plant pathogens tested. Copper-lime-arsenite preparations showed powerful fungicidal action by materials which went into solution gradually and diffused through the agar, whether the reaction of the medium was acid, neutral or moderately alkaline. The copper-lime component alone, however, showed no perceptible fungicidal action by diffused compounds when the medium was alkaline and very little when it was neutral or slightly acid. These studies and the field work show that the toxic properties of copper-lime-arsenite mixtures may be greatly varied by modifications in the amounts and proportions of the component materials, and by the choice of arsenites, which have a wide range of solubility and other important properties.

It is not suggested that these eradicant fungicides will be a cure-all or even that they will find adaptation against the diseases on which we are making preliminary experiments. They have not yet been proved to deserve a place in the control program against any disease. They are discussed here to illustrate a type of sanitary measure that seems to have been much neglected and to invite attention to a potentiality for future improvement in our disease control programs.

These brief excerpts from experience with apple scab will have served their purpose if they have illustrated (1) the need for a sounder scientific foundation for our orchard disease control programs, and (2) the desirability of supplementing the limited and temporary effectiveness of our protectant measures with the more enduring values that may be derived from increased application of the principles of eradication and immunization.

The need for correlation of effort.—In the foregoing discussion an attempt has been made to point out possibilities for improving orchard disease control by the development of programs of complementary measures soundly based on adequate experimentation. I wish now to invite attention to the need for correlation of efforts, both in the researches basic to the improvement of disease control programs and in relating

these programs appropriately to the other necessary procedures of orchard practice.

We have already observed that problems of the epidemiology and control of orchard diseases vary greatly with regional, seasonal and other factors. Programs that are satisfactory in one region or season may fail in another. The experience gained in one situation may not therefore be applied safely to others without adequate check under a suitable range of conditions. Consequently it is necessary in the case of the more important orchard diseases that studies be conducted in many places and over a sufficient term of years. It is fortunate that various state agencies and the U. S. Department of Agriculture are providing facilities for such studies; and the fact that work is done in many places is a factor of strength rather than weakness in the program as a whole. However it would seem that much of value might be gained if there were (1) better opportunity for exchange of experience and counsel on the part of various workers on the same problems and (2) more adequate support for the basic research upon which further progress so largely depends.

A further need for correlation attends the problem of fitting the measures for disease control appropriately into the general program of orchard operations. For example, it may be very desirable from the standpoint of apple scab control to turn under the leaves in spring before primary infection occurs; but this cannot wisely be done at the expense of sound orchard practice. In a great many situations it is not a feasible procedure. Again, it is highly desirable from the point of view of control of such diseases as bitter rot of apple or brown rot of peach to dispose of all diseased or waste fruit. If the entomologist finds this a useful procedure for insect control and the horticulturist can find an economic utilization for some of the waste fruit, the value of the operation is further enhanced. The need for close and sympathetic relations between those who cultivate the several fields that contribute the scientific basis for orchard practice is self-evident, and has long been appreciated. This symposium is to me a very welcome step in the direction of mutual counsel and the correlation of effort. I trust that it may be but one of many that will further closer relations, not only between workers in the several fields of science concerned, but also between those who work in different institutions on similar problems.

OVICIDAL AND SCALICIDAL PROPERTIES OF SOLUTIONS OF DINITRO-O-CYCLOHEXYLPHENOL IN PETROLEUM OIL

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Since 1923, emulsions of lubricating oil have been used extensively for the control of insects during the dormant period. Certain insects in the

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dormant condition are very resistant to insecticides; for this reason rather large concentrations of oil are often recommended. The primary object of this part of the present investigation was to determine whether dinitro-o-cyclohexylphenol, which has shown rather unusual promise as a contact and stomach poison for certain insects, could be incorporated with a petroleum oil to obtain a more effective insecticide than the oil alone. Such a mixture of petroleum oil and dinitro-o-cyclohexylphenol would considerably reduce the amount of oil in the diluted spray, and in this way lessen the chances of tree injury without reducing the effectiveness of the mixture.

Historical.—For many years nitro-phenols have been known to possess insecticidal properties. As early as 1892, a preparation "Antinonnine," which consisted of potassium 3–5 dinitro-o-cresylate and soap, was marketed by a German company (*3*, *4*). The ammonium and potassium salts of 3–5 dinitro-o-cresol and 3–5 dinitro-p-cresol were found by Jackson & Lefroy (*8*) to be toxic as stomach poisons for the house fly. The ortho-cresylates were more effective than the para-cresylates. William Moore (*11a*) determined that o-nitrophenol was toxic in the gaseous state to the house fly. He later found (*11b*) that p-nitrophenol in combination with creosote and talc was effective against the clothes louse *Pediculus humanus* (L.). Cooper & Walling (*5*) found that ortho and para-nitrophenol were toxic to blow fly larvae. Hargreaves (*7*) tested several nitro-phenols as stomach poisons for certain species of lepidopterous larvae and obtained results comparable to those of Jackson & Lefroy. Even dinitrophenol gave indications of toxicity as a stomach poison. An extensive investigation of the relative toxicity of nitrophenols as contact poisons was made by Tattersfield *et al.* (*16*). They studied a series of nitro-phenols and concluded that 3–5 dinitro-o-cresol was the most toxic to *Aphis rumicis* L. and to eggs of *Selenia tetralunaria* Hufn. Several nitro-phenols were included in the list of organic compounds tested by McAllister & Van Leeuwen (*9*) against newly hatched codling moth larvae. 2–4 dinitrophenol, 3–5 dinitro-o-cresol, and 2–6 dinitro-4-chlorophenol were among those compounds which gave the most promising results.

The above resumé of the literature pertaining to the use of nitrophenols in combinations other than petroleum oil is not exhaustive; only the more pertinent papers have been reviewed.

The number of publications concerned with the toxicity of mixtures of nitro-phenols and petroleum oil are few. It was reported (*2*) that 3–5 dinitro-o-cresol increased the effectiveness of oil sprays to eggs of the mealy plum aphid *Hyalopterus arundinis* (Fab.). Ralph H. Smith (*13*) was unsuccessful in attempting to increase the effectiveness of highly refined spray oils by the addition of toxic organic compounds. Among the substances tested was 3–5 dinitro-o-cresol. McGovran (10) determined the toxicity of several nitro-phenols in unemulsified white oil to newly hatched codling moth larvae. The mixtures which included 2–4 dinitrophenol and 3–5 dinitro-o-cresol in petroleum oil gave only slightly higher net controls than oil alone.

In the present investigation, a number of nitro-phenols dissolved in

petroleum oil have been tested as contact insecticides. The compound which showed consistently the highest toxicity was dinitro-o-cyclohexylphenol. This paper gives a report on the toxicity of solutions of the compound in petroleum oil to the San Jose scale *Aspidiotus perniciosus* Comstock and to eggs of a plant bug, *Lygaeus kalmii* Stål.

Materials.—The eggs of *Lygaeus kalmii* were well suited for the ovicidal experimentation. The eggs can be obtained easily during the winter months (*12*) and have a high percentage of fertility. They stand rather rough treatment without noticeable injury and are quite resistant to ovicides.

Overwintering San Jose scales, which were collected from infested apple trees in the vicinity of Ames, Iowa, were employed in the scalicidal tests.

The organic compound[2] with which this investigation is concerned is dinitro-o-cyclohexylphenol, or more specifically 2–4 dinitro-6-cyclohexylphenol, a yellowish-white crystalline substance, practically insoluble in water, soluble in petroleum oil, and having a melting point of 106° C.

The petroleum oil (Diamond paraffin oil) employed in the experiments had the following specifications: Sp. gr. (20° C) .8815; sulfonation value 82 per cent; viscosity (Saybolt, 100° F) 99–100 seconds, and (140° F) 53–54 seconds; boiling range 606°–742° F.

Preparation of emulsions.—Stock petroleum oil emulsions and emulsions containing varying amounts of the compound dissolved in the oil phase were prepared in the laboratory according to the following formula: petroleum oil plus the compound 75 per cent by weight, casein 2 per cent, and ammonia water (NH_3—28 per cent) 23 per cent. The petroleum oil containing the dissolved compound was gradually dispersed in ammonium caseinate solution (the outside phase), which had been previously homogenized in a glass dispensing mortar. Upon completion of the addition of the petroleum oil mixture, the agitation was continued for about 10 minutes to reduce the drop size within the desired range of one to 10 microns. Every effort was made to prepare the emulsions as uniformly as possible inasmuch as differences in the degree of dispersion of the oil might produce heterogeneous results.

Method of comparing the toxicity of ovicides.—The results of preliminary tests with *Lygaeus* eggs indicated that the variability was considerably reduced and that points on the toxicity curves were more congruous if the bugs that died immediately after hatching were included in the calculated mortalities. In the following method, therefore, the embryonic and post-embryonic mortalities have been pooled to furnish a measure of the total effectiveness of the ovicide.

Eggs deposited over a 24-hour period were placed in a small beaker and thoroughly mixed to insure homogeneous sampling. The ova were drawn in sample lots of 50. Each sample was scattered evenly over the center of a moistened semi-crepe type of filter paper (9 cm. in diameter) contained in a petri dish of standard size, and care was taken to prevent the eggs from coming in mutual contact. The petri dish containing the eggs was placed in an apparatus similar to that described by Tattersfield

[2] U. S. Patent No. 1,880,404. The compound was prepared by the research laboratories of the Dow Chemical Company, Midland, Mich.

& Morris (*15*) and sprayed with 2.5 cc. of a specified diluted emulsion at a pressure of 10 pounds per square inch. Upon removal of the dish from the apparatus, the excess spray liquid was drained and the exposed glass of the dish was wiped clean. The controls were treated with the same technique with the exception that water was used instead of a diluted emulsion. The dishes with the treated eggs were arranged in a chamber at a constant temperature of 30° C and a relative humidity of about 85 per cent. Six days in the incubator was ample time[3] for all the eggs to hatch. In determining the results of a treatment, the number of eggs that yielded healthy bugs, eggs that failed to hatch and bugs that died immediately following emergence were recorded.

Since the healthy bugs soon leave the dishes in search of food, it was easy to formulate a criterion regarding the post-embryonic mortality. The bugs that died on the filter papers were considered to have been so weakened by the toxic action of the ovicide that death ensued before escape from the dish was possible. To make certain that the oil films which remained on the inside walls of the dishes did not delay or prevent live bugs from escaping, the filter papers with their respective lots of eggs were transferred to clean dishes before hatching began. The live bugs were prevented from migrating to other dishes by coating the lower outside edge of each dish with a small amount of white oil.

After the incubation period, examination of the treated eggs showed that the embryos had died at various stages of development. This was evidenced by the color of the eggs. Some were straw colored, indicating that the embryos died soon after the eggs were sprayed; other were dark-yellow, indicating that the embryos developed for a period before succumbing to the mixture. Still other ova were orange-red in color. These eggs had almost reached the point of hatching, but the embryos were so weakened by the poison that they were not able to break through the chorion. Some of the fully developed embryos broke through the egg shell but died immediately after. In order to complete the mortality data, it seemed desirable to include these post-embryonic deaths.

The mortality determinations were made soon enough after hatching so that starvation could not have been responsible for the deaths. A check was made to determine whether the dried spray material remaining on the filter papers could have been responsible. Before hatching, eggs were transferred to a clean filter paper, but the bugs died regardless. The deaths were caused by the treatment the eggs received while the embryos were in the earlier stages of development.

In contrast to the results obtained with eggs treated with the toxic mixtures, the control eggs hatched and most of the young bugs immediately left the petri dishes in search of food.

A good ovicide does not necessarily have to prevent all eggs from hatching provided the bugs that hatch from the remaining eggs die immediately following emergence. This point has been neglected by previous workers and should be evaluated in comparing the toxicities of ovicides.

[3] The difference in the time of hatching of the eggs in the controls and those sprayed with the more toxic mixtures of petroleum oil was about 24 hours. This delay made it necessary to wait at least 24 hours beyond the usual incubation period.

Method of comparing the toxicity of substances to the San Jose scale.[4]—Branches about one-half inch in diameter and well infested with the scales were pruned and the main branches were cut in lengths of 12 to 16 inches. Each of the lengths was subdivided into a group of five or six pieces depending on the number of different materials to be tested. One stick from each group was set aside for the control and the remaining sticks were sprayed with the emulsions containing varying percentages of dinitro-o-cyclohexylphenol dissolved in the oil phase. The pieces were chosen at random from the groups and were maintained in a definite order with respect to the groups and the treatment received.

Table 1.—Toxicity of emulsions of dinitro-o-cyclohexylphenol dissolved in petroleum oil to eggs of *Lygaeus kalmii* Stål.

Treatment	Per cent Oil + DNOCHP in Dilution	Per cent DNOCHP in Oil Phase	Sample Number[6]	Number dead		Total No. Dead	Mean Percentage Mortality of DNOCHP-Oil-Mixture	Net Mortality of DNOCHP[7]	Total Chi-Square (x^2)[8]
				Embryos	Hatched bugs				
Petroleum oil[5]	1		250	21	5	26	10.4	0	
Oil+DNOCHP	1	.1	250	29	5	34	13.6	3.6	
Oil+DNOCHP	1	.5	300	80	19	99	33	25.2	
Oil+DNOCHP	1	1	300	144	37	181	60.3	44.3	
Oil+DNOCHP	1	2	300	126	120	246	82	79.9	
Oil+DNOCHP	1	3	300	128	134	262	87.3	86	
Oil+DNOCHP	1	5	250	110	132	242	97	96.6	40.733
Oil+DNOCHP	1	6.67	250	117	133	250	100	100	(P=.55)
Petroleum oil	2		500	204	9	213	42.6	0	
Oil+DNOCHP	2	.1	500	273	34	307	61.4	32.8	
Oil+DNOCHP	2	.5	500	342	32	374	74.8	55.8	
Oil+DNOCHP	2	1	400	277	100	377	94.2	89.9	
Oil+DNOCHP	2	2	400	269	120	389	97.2	94.8	53.594
Oil+DNOCHP	2	3	400	277	121	398	99.5	99	(P=.55)
Petroleum oil	3		500	280	22	302	60.4	0	
Oil+DNOCHP	3	.1	500	311	56	367	73.4	32.4	
Oil+DNOCHP	3	.5	500	338	116	454	90.8	77.5	
Oil+DNOCHP	3	1	300	185	107	292	97.3	93.7	50.626
Oil+DNOCHP	3	2	300	184	115	299	99.7	99.3	(P=.14)
									15.613
Controls			750	31	0	31	4.1		(P=.3-.5)

Each piece was impaled on the end of a dissecting needle, inserted through a hole at the base of the bell jar of the apparatus, and sprayed with 2.5 cc. of a diluted emulsion at 10 pounds pressure. The needle was revolved continuously during the spraying procedure in order to insure complete coverage of the scale. The stick was then removed from the needle and set aside with the corresponding control of the group. After treatment, the groups were placed at constant temperature (30° C) and humidity (about 70 per cent) for a period of 72 hours, at the end of which the mortality determinations were made. Preliminary tests showed that 72 hours was sufficient time, for when the time was increased beyond 72 hours the mortality of the control scales increased rapidly. It was therefore very important that the scales be checked at the end of the 72-hour period.

[4] A paper by the senior author on a laboratory method of comparing the toxicity of substances to the San Jose scale will be published in this JOURNAL, Vol. 29. Since the experimental design with a statistical analysis is given in detail in this forthcoming publication it will suffice here to give only a brief account of the technique.

[5] DNOCHP = Dinitro-o-cyclohexylphenol.

[6] Subsample number = 50 eggs.

[7] Determined by formula (1) $x-y/x(100)$ = net mortality, where x = percentage living in oil-treated group, and y = percentage living in group treated with oil + DNOCHP.

[8] Total value of chi-square with probability of death (P) for data of each curve. See results for interpretation.

The covers were carefully lifted from 60 overwintering scales that were examined at random from all parts of each of the sticks or branch sections of the groups. Failure of the scale to respond when probed with a dissecting needle, a marked shrivelling, and an orange-brown color, the latter contrasting with the lemon yellow color of the normal live scale, were employed as criteria of death.

Ovicidal results.—The results of the ovicide experiments with emulsions of dinitro-o-cyclohexylphenol dissolved in petroleum oil have been summarized in table 1. The mean percentages of mortality given are average (weighted mean) values for the subsample mortalities under each dilution of petroleum oil and petroleum oil plus the dinitro-compound.

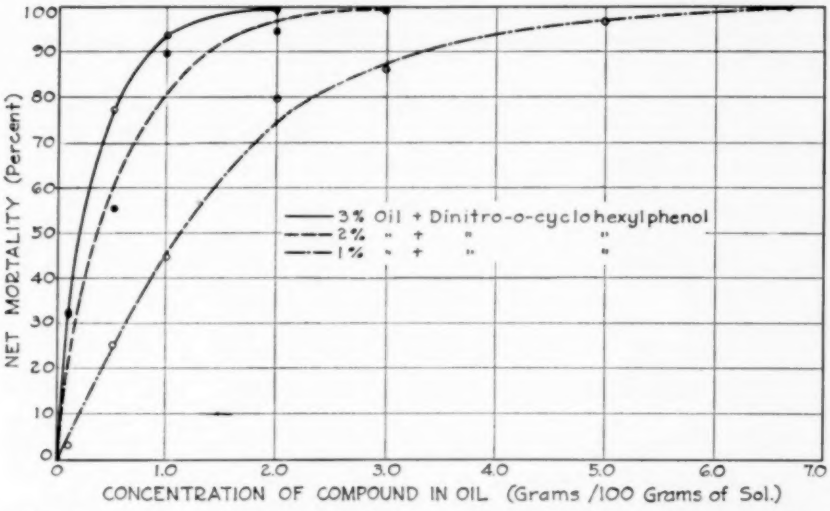

Fig. 1.—Toxicity of solutions of dinitro-o-cyclohexylphenol in petroleum oil to eggs of *Lygaeus kalmii* Stål.

The net mortalities have been arranged in the table directly opposite the mean percentage mortalities, and were calculated by means of the well-known formula (*1*). In calculating these net mortalities petroleum oil was used as the basis for comparison in order to evaluate the toxicity of the dinitro-compound over and above the toxicity of the petroleum oil. The mean mortality of the controls is included in the mean mortalities given in the table for the three dilutions from the stock oil emulsion. The net mortalities for the petroleum oil emulsion without the dinitro-compound based on the controls are 6.6, 40.2 and 58.7 per cent for stock dilutions of 1, 2 and 3 per cent respectively. The data for the net mortalities as given in table 1 were plotted against their respective concentrations in per cent of the dinitro-compound dissolved in the oil phase of the diluted emulsions. The resultant curves are illustrated in fig. 1. The three toxicity curves in fig. 1 show the concentrations of dinitro-o-cyclohexylphenol dissolved in the oil phase that were required to give 99

to 100 per cent net mortality. Using a stock emulsion dilution of 1 per cent by weight of oil plus the dinitro-compound, 6.67 per cent of the compound dissolved in the oil phase was required to give 100 per cent net mortality. A stock dilution of 2 per cent by weight required 3 per cent of the dinitro-compound dissolved in the oil phase, whereas a stock dilution of 3 per cent required 2 per cent of the dinitro-compound.

The original ovicidal data were analyzed for homogeneity by means of the chi-square (χ^2) test.[9] The object was to ascertain whether the differences among the mortalities of the subsamples were of a magnitude ascribable to the chances of random sampling. The analysis is a critical test of the adequacy of the ovicidal method and the uniformity of the egg population.

Table 2.—Toxicity of emulsions of dinitro-o-cyclohexylphenol in petroleum oil to the San Jose scale.

Treatment	Per cent Oil+DNOCHP in Dilution	Per cent DNOCHP in Oil	Sample Number[10]	Number Dead		Mean Percentage Mortality of DNOCHP-Oil-Mixture	Net Mortality of DNOCHP[7]
				Total Number	Subsample Range		
Petroleum oil	1	0	1020	516	17–47	50.6	0
Petroleum oil+DNOCHP[8]	1	1	1020	768	37–58	75.3	50
Petroleum oil+DNOCHP	1	5	1020	906	44–60	88.8	77.4
Petroleum oil+DNOCHP	1	1	1020	996	54–60	97.6	95.2
Petroleum oil+DNOCHP	1	2	1020	1012	58–60	99.2	98.4
Petroleum oil+DNOCHP	1	3	1020	1020	60–60	100	100
Control				162	3–16	15.9	
Petroleum oil	2	0	900	770	37–57	85.6	0
Petroleum oil+DNOCHP	2	1	900	859	53–60	95.4	68.4
Petroleum oil+DNOCHP	2	5	900	885	57–60	98.3	88.4
Petroleum oil+DNOCHP	2	1	900	898	59–60	99.8	98.4
Petroleum oil+DNOCHP	2	2	900	900	60–60	100	100
Control			900	156	5–23	17.3	

The total values of chi-square are given in table 1 for the data of each stock dilution of petroleum oil or oil plus the dinitro-compound. The total chi-squares were obtained by the summation of the contributing values of chi-square for each sample. In parentheses are given the probabilities of occurrence of such values of chi-square in random sampling. The values are in each case greater than .05, the generally accepted limit of significance. Since the probabilities lie between .1 and .9 there is no reason to suspect that the differences in the mortalities of the subsamples are otherwise than chance deviations, *i.e.*, the subsample mortalities with the different treatments and in the controls vary only so much as would be expected in random sampling from a homogeneous population. It can be concluded that within the limits of experimental error the egg population was homogeneous and the technique of handling it was adequate.

Scalicidal results.—The results of the toxicity experiments with emulsions of dinitro-o-cyclohexylphenol dissolved in petroleum oil and applied to San Jose scale are summarized in table 2. The mean percentage mortalities and the net mortalities as compared with petroleum oil were

[9] The method of computation for the case of unequal frequencies has been outlined by Snedecor & Irwin (*14*). Tables of chi-square and probability in Fisher's book (*6*) were employed.

[10] Subsample No. = 60 scales.

derived in the same way as those of table 1. The net mortalities of the dinitro-compound as compared with the petroleum oil were plotted against their respective concentrations in per cent of dinitro-compound dissolved in the oil phase of the diluted emulsions. The two curves that are illustrated in fig. 2 were obtained by using stock emulsion dilutions of 1 and 2 per cent by weight of petroleum oil plus the dinitro-compound. Stock emulsion dilutions of 1 per cent required 3 per cent of the dinitro-compound in the oil phase to give 100 per cent net mortality of

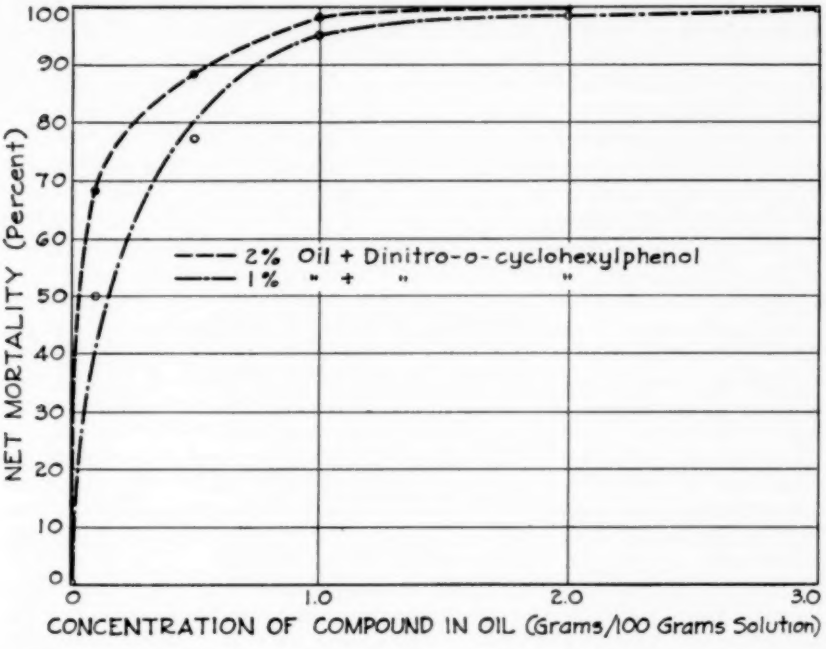

Fig. 2.—Toxicity of solutions of dinitro-o-cyclohexlyphenol in petroleum oil to the San Jose scale.

San Jose scale. Net mortalities of 98 per cent were obtained with only half the concentration of dinitro-compound in the oil phase required for 100 per cent net mortalities.

Discussion of results.—The toxicity of dinitro-o-cyclohexylphenol in petroleum oil was evaluated as net percentage mortalities over and above petroleum oil toxicity. It should be emphasized that these data, as given in tables 1 and 2 and plotted in figs. 1 and 2, show not only the percentage increase in toxicity above petroleum oil but include, in addition, the possible factor of synergistic effect. This kind of activation is not well understood, but is recognized on the basis that the toxicity of a petroleum oil solution of dinitro-o-cyclohexylphenol is greater than the sums of the toxicities of the components. It is believed that the petroleum oil serves as a toxic solvent and synergist for the more toxic dinitro-compound be-

cause of the known toxicity of this compound when applied in certain other ways.

The dispersed oil globules that contain dinitro-o-cyclohexylphenol in solution break from the aqueous phase directly on the surface of the egg or scale. The amount of the dinitro-compound present in the continuous or outside phase is very small and its bearing on toxicity is probably nil. For these reasons the concentrations of dinitro-o-cyclohexylphenol were expressed in terms of per cent (grams per 100 grams of solution) of the dinitro-compound dissolved in the petroleum oil phase. If the concentrations had been given in per cent of the dinitro-compound in the diluted emulsion, a 1 per cent dilution of petroleum oil plus 3 per cent of the dinitro-compound would contain .03 per cent of the compound in the diluted emulsion.

The results of the toxicity experiments with solutions of dinitro-o-cyclohexylphenol in petroleum oil have demonstrated that only a relatively small concentration of oil is necessary to carry an effective concentration of the dinitro-compound. For example, a 100 per cent net mortality of San Jose scale was obtained with an oil mixture diluted to a spray strength of 1 per cent and containing 3 per cent of the dinitro-compound dissolved in the oil phase of the emulsion. Laboratory experiments have shown that a dilution of 3 per cent of petroleum oil without the dinitro-compound is necessary to furnish about an equally effective mortality of scale. In the ovicidal experiments, a 100 per cent net mortality was obtained with a 1 per cent dilution of the oil mixture containing 6.67 per cent of the compound dissolved in the oil phase. A dilution of 3 per cent oil without the dinitro-compound gave only 59 per cent net mortality of eggs. These mixtures of petroleum oil plus dinitro-o-cyclohexylphenol considerably reduce the amount of oil in the diluted sprays without reducing the effectiveness of the mixture for control of the eggs and scale.

Because of the specificity of insecticidal action, it is not reasonable to assume that the solutions of dinitro-o-cyclohexylphenol in petroleum oil will control all species of injurious insects. However, other laboratory tests have shown that solutions of dinitro-o-cyclohexylphenol in petroleum oil were effective against eggs of the squash bug *Anasa tristis* DeGeer, the Colorado potato beetle *Leptinotarsa decemlineata* (Say), and a sod webworm moth, *Crambus teterrellus* Zincken. Also, recent laboratory experiments have demonstrated that the lethal concentrations established for the San Jose scale were very effective for the control of the European elm scale *Gossyparia spuria* Modeer.

These laboratory experiments with solutions of dinitro-o-cyclohexylphenol in petroleum oil have in general compared favorably with field experiments conducted by Dutton.[11] The field results have been very promising and the use of the mixtures for the control of insects during the dormant period is indicated.

Summary.—The toxicity of solutions of dinitro-o-cyclohexylphenol

[11] **Dutton, W. C.** Orchard trials of dinitro-o-cyclohexylphenol in petroleum oil for control of rosy apple aphis and San Jose scale. This paper appears in this JOURNAL, p. 62.

in petroleum oil has been determined in the laboratory for the San Jose scale and eggs of *Lygaeus kalmii*.

A method has been given for comparing the toxicities of ovicides to the *Lygaeus* eggs. In the method proposed, the embryonic and post-embryonic mortalities were pooled to furnish a measure of the total effectiveness of the ovicide.

A method for comparing the toxicity of substances to the San Jose scale has been reviewed. Only a brief account of the design and technique is given here.

Lethal concentrations have been established with respect to the amount of dinitro-compound dissolved in the oil phase of the emulsions and the concentrations of oil plus the compound in the diluted sprays. Toxicities of the mixtures for eggs and scale are represented by curves.

It has been determined that because of the high toxicity of the dinitro-compound, only a relatively small concentration of oil is necessary to carry an effective concentration of it.

The use of the mixture for control of insects during the dormant period is indicated.

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ORCHARD TRIALS OF DINITRO-O-CYCLOHEXYLPHENOL IN PETROLEUM OIL FOR CONTROL OF ROSY APPLE APHIS AND SAN JOSE SCALE

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Orchard trials of several organic compounds were made in 1934 to determine their efficiency against the eggs of the rosy apple aphis *Anuraphis roseus* Baker and the black cherry aphis *Myzus cerasi* Fabricius. These orchard trials were made in conjunction with the laboratory studies reported in the preceding paper by Richardson & Kagy. The compound which gave the best results is dinitro-o-cyclohexylphenol. It was dissolved in a petroleum oil of the lubricating type (viscosity Saybolt 100 sec., sulfonation value 82 per cent, specific gravity .8815, distillation range 606 to 742° F). This oil solution of the dinitro-o-cyclohexylphenol was then emulsified with sodium caseinate. This gave, when used as a dormant application, practically complete control of both the rosy apple aphis and the black cherry aphis at concentrations that apparently are entirely safe to the trees. The infestation of aphis was relatively light in 1934 so that the results were not conclusive, but definite enough to indicate high ovicidal efficiency. Further and more extensive trials were made in 1935 against the rosy apple aphis, the black cherry aphis and San Jose scale *Aspidiotus perniciosus* Comstock.

Experiments in 1935.—The solution of dinitro-o-cyclohexylphenol in oil was used in 1935 in three types of preparations and each with two or three concentrations of DNOCHP (dinitro-o-cyclohexylphenol) in the concentrated material. The three types of preparations were (1) sodium caseinate emulsions with 2, 3 and 5 per cent DNOCHP content, (2) tank mixtures (with blood albumen emulsifier) of clear solutions of DNOCHP in oil with 3 and 5 per cent toxicant content, and (3) miscible oil type of preparations with 2, 3 and 5 per cent toxicant content. Each material was used in amounts to give .025, .05, .1 and .15 per cent of the toxicant in the dilute spray. The concentrations of actual oil in the dilute sprays varied from .35 to 5.64 per cent and the ratio of oil to toxicant varied considerably in the different preparations.

Period of application.—The applications for aphis control on apple and cherry were made during the first half of April, during which period the trees were in a rather advanced dormant condition. That is, the blossom buds were noticeably swollen and in some instances tips of blossom buds were visible. The applications for San Jose scale control were made a little later and many of the trees were in a well-developed delayed dormant condition when sprayed.

Varieties.—The aphis control work on apples was confined to varieties that are known to be susceptible to aphis attack—Chenango, Rhode Island Greening and Jonathan. The scale control tests were made with

[1] Journal article 246 (n.s.) from the Michigan Agricultural Experiment Station. Early publication of this paper has been secured by payment of the printing charge.

Grimes, and Schmidt's Bigarreau was the variety of sweet cherry used.

Plot layout.—The orchards in which this work was done are near South Haven and within a few miles of Lake Michigan. Single tree plots with several replications in each orchard were used. All plots were selected at random.

Observations and calculations.—Observations on aphis control on both apple and cherry were made in late June and July by counting infested or affected points. The term "point" as used here includes terminal and lateral shoots, suckers and fruiting and non-fruiting spurs. The infestation counts for the trees under a given treatment in each orchard were averaged. The average count from unsprayed controls was used as the basis for calculation. The "percentage control" for each treatment was calculated by the Abbott formula. The control figures for each treatment from all orchards and varieties were then averaged.

Table 1.—Control of rosy apple aphis and San Jose scale with a sodium caseinate emulsion of dinitro-o-cyclohexylphenol in petroleum oil.

Insect	Percentage Control from Four Concentrations of Actual Oil and Toxicant (Per Cent by Wt. in Dilute Spray)			
	.6–.025	1.2–.050	2.4–.100	3.6–.150
Rosy apple aphis	95	98	99	100
San Jose scale	91	99	100	

The number of trials for each treatment discussed range from two to six. These trials were distributed over Chenango in three orchards, Jonathan in one and Rhode Island Greening in two orchards. The results for cherry aphis control were obtained and calculated in the same manner.

Counts of San Jose scale were made for all treatments and checks both before and after the spraying period. The average percentage of live scale before spraying was about 15 per cent for all plots. This is probably about normal for Michigan. The later counts were made about one month after application. The results presented in this paper were calculated by the Abbott formula which uses the percentages of live scale on sprayed and unsprayed trees at the "after spraying" period. The percentages of live scale were figured from observations of 1000 scale (200 per tree for five trees) for each treatment.

More data are available for the preparations of each type containing 3 per cent of the toxic compound than for those containing 2 and 5 per cent. Furthermore, the 3 per cent toxicant content seems more desirable than either 2 or 5 per cent. In order to simplify the presentation of data, the statement of results will be confined to those obtained from the use of caseinate emulsion containing 3 per cent of the toxicant and 72 per cent of oil.

Rosy aphis control.—The results obtained with these materials in 1935 are undoubtedly significant as rosy aphis developed very seriously this year in many orchards. An idea of the extent of this development may be gained from a statement of the average number of infested points per tree on unsprayed trees. Of the three Chenango orchards, one, with many rather small trees, averaged 466 infested points per tree, the second with small to medium trees averaged 3337, and the third with

rather large trees 2166 per tree. The unsprayed Jonathan trees had 807 per tree. One orchard of Greening with moderately sized trees for the variety had 1444 and the other orchard with young trees had an average of 705 infested points for each unsprayed tree.

The percentage control obtained with the caseinate emulsion of DNOCHP and oil (72 per cent oil and 3 per cent toxicant) for each of four concentrations is shown in table 1 and the results are shown graphically in fig. 1.

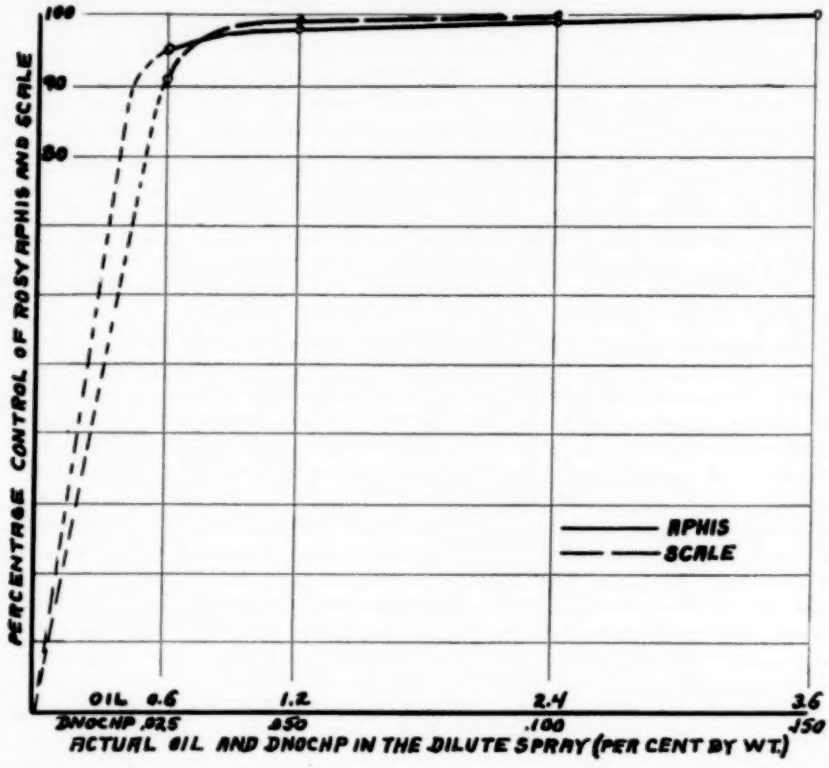

Fig. 1.—Control of rosy apple aphis and San Jose scale with dinitro-o-cyclohexylphenol in petroleum oil.

This shows very satisfactory commercial control (95 per cent) at the lowest concentration and from 98 to 100 per cent control at the higher concentrations.

The results from the use of the same amounts of DNOCHP in the tank mixture and miscible oil type of preparations gave essentially the same degrees of control of rosy aphis.

Cherry aphis control.—The data on black cherry aphis control are not so extensive as with the rosy aphis but there are definite indications

that the cherry aphis can be controlled with even lower concentrations of these sprays than are necessary to control apple aphis.

San Jose scale.—The data on San Jose scale control with the sodium caseinate emulsion of DNOCHP and oil (72 per cent oil and 3 per cent toxicant) are presented in table 1 and fig. 1, along with the data on aphis control. Scale counts were not made for any treatment where the actual oil concentration was more than 3 per cent. The percentage control for the lowest concentration of oil-toxicant was 91 per cent and was essentially complete at the higher concentrations. The tank mixture and miscible oil preparations of DNOCHP in oil gave the same high control at the intermediate concentrations as the caseinate emulsion, and slightly better control at the low concentration.

Other data, not presented here, indicate that low concentrations of oil to which DNOCHP has been added is more effective against San Jose scale than the same concentrations of straight oil.

Conclusions.—The data from orchard trials in 1935 indicate high efficiency for dinitro-o-cyclohexylphenol in petroleum oil against the eggs of the rosy apple aphis and the black cherry aphis. Concentrations of oil and toxicant that are effective against aphis eggs seem also to be entirely satisfactory for the control of San Jose scale. Less extensive trials indicate that the black cherry aphis can be controlled with as low, or possibly lower concentrations than are necessary for rosy aphis control.

Dilute sprays containing from 1.2 per cent oil and .05 per cent DNOCHP to 2.4 per cent oil and .1 per cent DNOCHP are undoubtedly adequate to give satisfactory control of the rosy apple aphis, the black cherry aphis and San Jose scale and without danger of injury to trees.

DIFFERENCES BETWEEN RESISTANT AND NON-RESISTANT RED SCALE IN CALIFORNIA

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During 1932, 1933 and 1934, an intensive study was made of fumigation with hydrocyanic acid gas for the control of the Red Scale, *Aonidiella aurantii*, Mask. Much of this work, particularly the portion dealing with orchard fumigation, has been reported (*6a*, *b*). During the work many fumigations were made in a tight metal fumatorium, previously described (*6a*) and it was found that these results did not always agree with the results obtained in orchard fumigations with comparable average concentrations. In making a study of the results of fumigations in the metal fumatorium, it was found that the resistant form of red scale found at Corona and the non-resistant form from La Canada gave different reactions to hydrocyanic acid. The work reported in this paper covers a series of tests designed to bring out these differences between the resistant and non-resistant forms of the red scale in California.

[1] Early publication of this paper has been secured by payment of the printing charge.

Methods.—Infested lemons were collected at Corona to represent resistant red scale, and at La Canada to represent non-resistent red scale, and used for fumigations in the fumatorium at Azusa. The collections were made the day before fumigation. A thin wire was attached to the stem of each lemon by which it was suspended in the shade so that the temperature of the lemon would become the same as that of its environment. The lemons to be fumigated were attached by the wires to an iron stand so that no lemon touched another. This stand was placed in the fumatorium and the dosage of liquid hydrocyanic acid was measured out and delivered to the fumatorium through heated coils. A fan was used in the chamber to stir and immediately equalize the incoming hydrocyanic acid gas. The concentration was determined by two to four gas analyses drawn during the fumigation. At the close of each fumigation the lemons were removed, aired, and then placed in a cool chamber for a period of two weeks. They were then exposed in an open screen room

Table 1.—Temperature effects on kills of resistant red scale resulting from fumigations conducted in a metal fumatorium and in a tent.

Temp. Range	Average Kill in Fumatorium per cent	Average Kill in Tent Fumigation per cent
50.1–55° F	95.84	99.42
55.1–60°	91.77	99.01
60.1–65°	87.69	99.66
65.1–70°		98.70
70.1–75°	85.59	99.51

for one to two days to dry out the bodies of the insects, after which the number of dead and living insects was determined. Check lemons were subjected to exactly the same treatment as the fumigated lemons except for the actual fumigation. The number of dead and living insects on these checks gave the natural mortality which was deducted from the counts of the treated insects in determining the kills due to fumigation.

In the case of the orchard fumigations the lemons were collected the day after the fumigation and placed in the cool chamber and handled the same as the lemons treated in the fumatorium.

Temperature Effects in Fumatorium and Tent Fumigations

In order to make a comparison of fumigations in the fumatorium with those under a tent it is necessary to use comparable concentrations. In a tent fumigation the concentration is high at the start but declines due to tent leakage. The concentration in the fumatorium is uniform from start to finish. Thirty-three such fumigations were made in which the concentrations were .08 to .09 per cent by volume. This concentration is the average concentration obtained in a 16-unit tent from the use of an 18 cc. schedule of hydrocyanic acid. These 33 fumigations in a fumatorium are compared with 97 orchard tests in table 1. In this table the average kills obtained at different temperature ranges are given.

An examination of these data shows clearly that the kill of resistant red scale is lower in the higher temperature ranges in the case of the fumigations conducted with a uniform concentration in a metal fumatorium.

This temperature effect is not apparent in the orchard work where the hydrocyanic acid is volatilized under a tent.

These results indicate that conclusions based upon fumigations in a tight metal fumatorium cannot be applied to orchard fumigations.

Comparison of Paired Fumatorium and Form-Tent Fumigations

The comparisons just made are not free of suspicion, since the field results were obtained in different orchards located in different resistant districts, whereas all the fumigations in the metal fumatorium were carried out with resistant insects from the same orchard at Corona. For this reason, another series of tests were made comparing the two types of fumigations with infested lemons from the same source, the orchard at

Table 2.—Comparison of kills of resistant red scale in paired fumigations conducted in a metal fumatorium and in a form tent.

No. of Test	Toxicity Constant in Fumatorium Concentration × Exposure	Kill in Fumatorium per cent	Toxicity Constant in Tent Concentration × Exposure	Kill in Tent per cent	Difference, Tent Kill and Fumatorium Kill per cent
1	3.654	74.86	3.057[2]	83.68	+8.82
2	3.765	83.03	2.336[2]	88.33	+5.30
3	3.906	98.36	3.754	100	+1.64
4	3.922	79.46	3.437[2]	87.79	+8.33
5	3.979	81.48	3.902	88.13	+6.65
6	4.021	73.65	3.045	96.51	+22.86
7	4.022	90.70	3.036[2]	90.32	− .38
8	4.032	89.54	3.539[2]	93.95	+4.41
9	4.491	99.30	4.069[2]	99.30	0
10	4.530	95.21	4.514	98.53	+3.32
11	4.716	96.91	3.999	99.65	+2.74

Corona. Paired fumigations were conducted simultaneously under the same temperature and relative humidity conditions in a form tent and in the metal fumatorium for a period of 45 minutes, using lemons which had been picked and handled as one unit previous to and after the fumigation. In some cases a five-unit form tent was used, in other tests a sixteen-unit form tent. Lemons fumigated in the tent were suspended in the same manner as that used in the fumatorium tests. Samples for analyses were drawn from the point where the lemons were suspended. Seven analyses of tent concentrations and four of fumatorium concentrations were made during each fumigation. In both fumigations the hydrocyanic acid was volatilized and applied as a gas. Dosages were varied by reducing the number of units or the schedule, or both. Comparisons were made only between the tent fumigations in which the toxicity constant, derived by multiplying the concentration by the length of exposure at that concentration, was the same or lower than that obtained in the paired fumigation at a uniform concentration in the metal fumatorium. The results are recorded in table 2.

The results given in table 2, interpreted by Love's modification of

[2] Five-unit form tent, others 16-unit form tent.

Student's method (*5*), indicate odds of 144–1 that the kill of resistant red scale obtained in a tent fumigation is better than that obtained in a metal fumatorium, although the toxicity constant of the fumatorium is higher than that of the tent. The average difference of kill was 5.79 per cent. The results indicate that the kills of resistant red scale obtained in a fumatorium cannot be used to indicate the results to be expected in a tent fumigation.

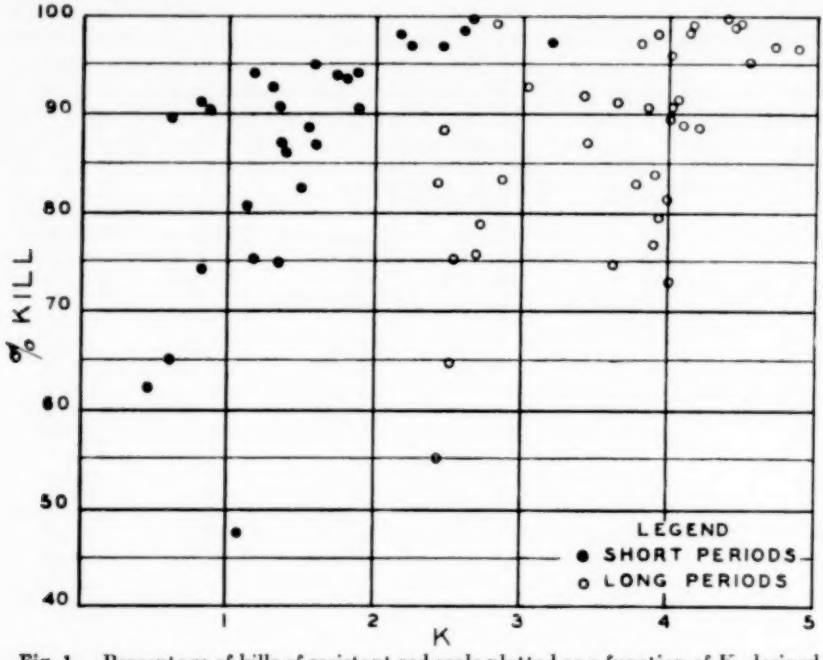

Fig. 1.—Percentage of kills of resistant red scale plotted as a function of K, derived by multiplying the concentration in per cent by volume by the length of exposure in minutes.

Reactions to Concentration and Exposure

One of the first questions is the reaction of the scale to the concentration and to the length of exposure in the fumatorium. Quayle & Knight (*7*) considered that in the fumigation of citrus trees the kill of the insects is related to a lethal constant derived by multiplying the concentration by the length of exposure. K = CT. Brinley & Baker (*3*), working with two species of aphids and one species of thrips, showed a similar relationship of concentration and length of exposure.

This lethal constant places an equal value on exposure and concentration. In order to determine whether the concentration and exposure are of equal value in the case of resistant red scale, a series of 66 fumigations were conducted in the fumatorium using, uniform concentrations. These fumigations consisted of 5, 10 and 45-minute exposures with differ-

ent concentrations of hydrocyanic acid, each of which was held at a constant level throughout the exposure. The results are charted in fig. 1.

It is clearly shown that for the short exposures of five and ten minutes the lethal constant (CT) for a 95 per cent kill lies between 2 and 3 whereas for the long 45-minute exposure the constant to obtain the same kill is between 4 and 5. Therefore, similar relationships exist for other kills. Concentration and exposure are not of equal value in effecting a

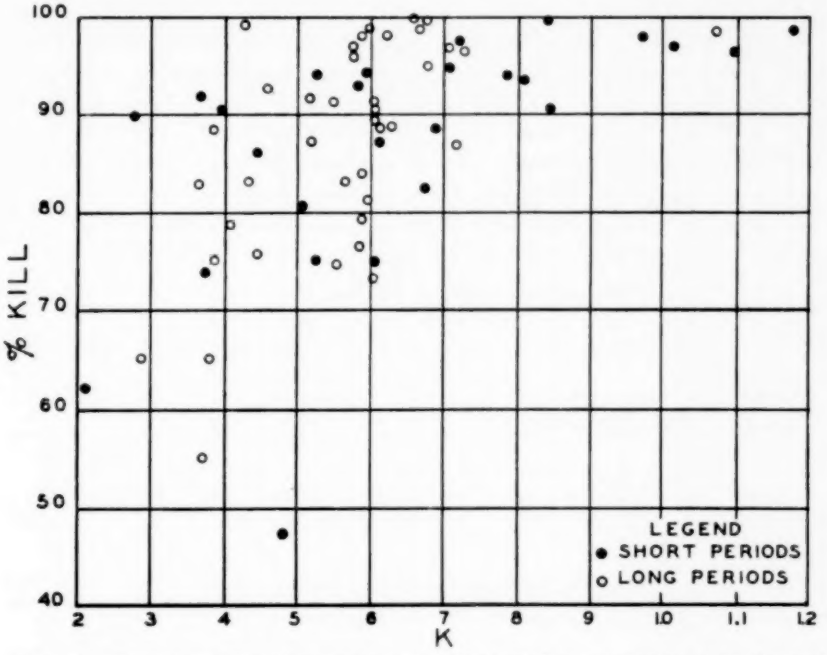

Fig. 2.—Percentage kills of resistant red scale plotted as a function of K, derived by multiplying the concentration in per cent by volume by the .5 power of the length of exposure in minutes.

kill of resistant red scale, the high concentration of the short periods having more value than the low concentration for the long exposures.

When the relationship of concentration and length of exposure are of unequal value the exponent of one or the other becomes greater or less than 1. A consideration of fig. 1 would indicate that the concentration was approximately double the value of this exposure in effecting the kill. This relationship may be expressed as $K = C^2T$ or as $K = CT^{.5}$. $K = C(T)^{.5}$, may be expressed as $K = C\sqrt{T}$. The data given in fig. 1 are rearranged upon this basis in fig. 2. The results obtained from short and long exposures are now evenly distributed and there is no difference between the lethal constant obtained from a short exposure with a high concentration and that obtained from a long exposure with a low concentration.

It is interesting to note that if the data presented in table 2 are recalculated for a toxicity constant of $CT^{.5}$, the tent toxicity constant is in all cases higher than that of the uniform concentration used in the metal fumatorium.

If the lethal constant for the resistant red scale is $CT^{.5}$ the question arises as to the values to be placed upon the exposure and the concentration in the case of the non-resistant red scale. A series of fumigations of non-resistant red scale for 5, 20 and 45-minute exposures with different concentrations of hydrocyanic acid were made in the fumatorium. The concentration and exposure relationship determined from these

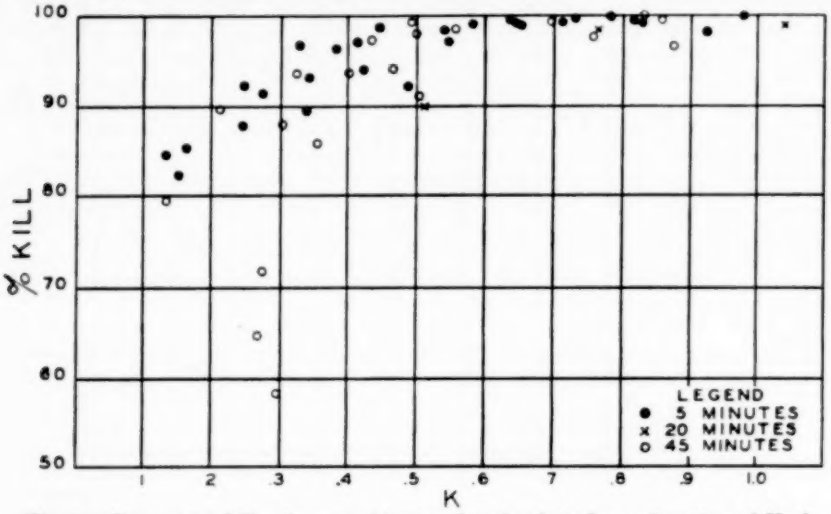

Fig. 3.—Percentage kills of non-resistant red scale plotted as a function of K, derived by multiplying the concentration in per cent by volume by the .8 power of the length of exposure in minutes.

tests indicated that concentration and exposure were of nearly equal value, but could best be expressed by the formula $K = CT^{.8}$, fig. 3.

Comparisons of Kills of Resistant and Non-resistant Red Scale

By the preceding experiments it was shown that in the case of resistant red scale the results of short exposures with high concentrations and long exposures with low concentrations may be fitted together by the expression $CT^{.5}$, whereas in the case of the non-resistant red scale the results are fitted by the expression $CT^{.8}$. The question arises as to whether the results of fumigations of resistant and non-resistant red scale can be fitted together by the use of the above expressions. If K expressed as $CT^{.5}$ for the resistant type is equal to K derived from $CT^{.8}$ for the non-resistant form, will the kills be comparable?

The regular sigmoid toxicity curve may be converted to a straight line by plotting the concentration in logarithms and the kill in probits

(*2a*). In a similar manner the relationship between the lethal constants and the kills for either resistant or non-resistant red scale may be expressed as a straight line. In this case log. K = log. C + .5 log. T for resistant scale, and log. K = log. C + .8 log. T for non-resistant scale. The kills would be recorded in probits.

During the work, 80 fumigations were conducted in the metal fumatorium, using resistant red scale, and 71 similar fumigations were made on non-resistant red scale. These tests were at different seasons, in

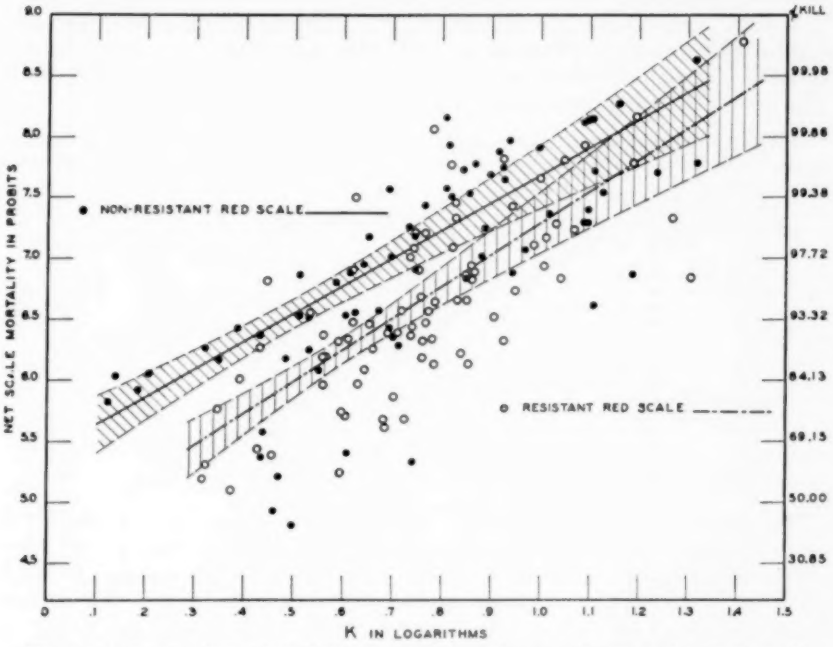

Fig. 4.—A comparison of the kills of resistant and non-resistant red scale in probits plotted as a function of the log. K. Log. K = log. C + .5 log. T + log. 10 for resistant scale, and log. K = log. C + .8 log. T + log. 10 for non-resistant red scale. C equals the concentration in per cent by volume, T equals the length of exposure in minutes, and the log. 10 is added to each to make log. K positive values.

different years, and represent the entire range of temperature and relative humidity encountered in fumigation. The exposures were for 5, 10, 20, 30, 45, 60 and 90 minutes. The analyses of the data were made by Dr. C. I. Bliss using the methods recorded in his papers (*2a*, *b*).

Figure 4 gives the curves and zones of error computed from Bliss (*2a*), Equation 12.

For the two series, the final curves and their errors within odds of 19 to 1 were:

$$\text{Resistant scale: } Y = 6.2937 + 2.6132(X - .6168) \pm 1.9915\sqrt{.002995 + (X - .6168)^2 .09175}$$

$$\text{Non-resistant scale: } Y = 6.5499 + 2.2745(X - .5005) \pm 1.9956\sqrt{.003468 + (X - .5005)^2 .06633}$$

In these equations Y is the expected probit mortality, and to make all values of the log. of K positive the lethal constants are given as log. of 10K and recorded as Y. K used for the resistant scale is $C(T)^{-5}$ and for the non-resistant scale $C(T)^{-8}$.

The weight of the individual tests varied from 1.6 to 465.9 in the resistant series and from 1.9 to 5059.1 in the non-resistant series. This wide variation in the weight of the individual points is the explanation of any apparent lack of agreement between the connected curves and the plotting points.

Both series varied more from their log · lethal constant probit mortality relationships than could be expected on the basis of their sampling errors, as indicated by the following values for X^2, Equation 7 of Bliss (*2a*), both of which were much larger than that for $P = 0.01$.

Table 3.—Sixteen fumigations of resistant and non-resistant red scale together in the same fumatorium with uniform concentrations for an exposure of 45 minutes.

Concentration, % by Vol.	Temp. °F	Per cent Relative Humidity	Resistant Scale Lethal Constant CT^{-5}	Resistant Scale Kill, %	Non-Resistant Scale Lethal Constant CT^{-8}	Non-Resistant Scale Kill, %
.0309	72	71	.207	57.75	.649	99.83
.0396	67	79	.266	66.85	.832	100
.0578	64	38	.388	65.71	1.214	98.91
.0589	66	36	.395	56.60	1.238	98.90
.0589	66	36	.395	77.05	1.238	100
.0591	70	33	.396	91.04	1.242	99.18
.0598	55	43	.401	95.69	1.257	100
.0608	62	45	.408	87.59	1.278	94.71
.0608	58	53.8	.408	90.98	1.278	99.67
.0633	81	27	.425	56.05	1.330	99.45
.0683	59	52	.458	89.57	1.435	100
.0729	55	51.5	.489	78.26	1.532	96.89
.0815	58.5	44	.547	94.90	1.713	99.66
.0961	65	44	.645	89.03	2.020	99.88
.0977	58	41	.655	99.72	2.053	100
.0984	73	22	.660	98.06	2.068	99.73

Resistant Series $X^2 = 2468.8$. Non-resistant Series $X^2 = 11405.6$. In consequence, the variances of position, $V^{(a)}$, and of slope, $V^{(b)}$, were determined from the observed variation as given by Equations 8 and 9 of Bliss (*2a*). For the same reason, a comparison of the two parameters of position $^{(a)}$ and of slope $^{(b)}$ required the *t* tests rather than X^2. From Equation 24 of Bliss (*2b*) $t_a = 6.287$ with 147 degrees of freedom and $P < .01$, from which it is concluded that the two series differed significantly in their susceptibility, despite the fact that the graphic zones of error overlapped at the upper end. From Equation 26 of Bliss (*2b*) $t_b = .852$ with 147 degrees of freedom and $P = .396$, which indicates that the two series had substantially the same slope, or that a given percentage increase in dosage produced relatively the same increase in kill in both resistant and non-resistant scale.

A better comparison would be the fumigation of resistant and non-resistant red scale in the fumatorium at the same time. In this case at least the temperatures and relative humidities before, during and after the fumigation would be the same for both series. The results of 16 such fumigations are given in table 3.

In each test, both resistant and non-resistant red scale were fumigated together in the metal fumatorium, with the same concentration and the same exposures. Although the two types of red scale are subjected to the

same concentration and exposure in such a test, the relative value of these two factors for the two insects are different, hence different results are to be expected. If the kill is a function of the lethal constant the kill of non-resistant red scale should be higher, since the lethal constant is higher in any test where the insects are fumigated together. Will the mortality curve computed for the resistant scale on the basis of $K = C(T)^{.5}$ be a satisfactory fit for the non-resistant red scale with $K = C(T)^{.8}$?

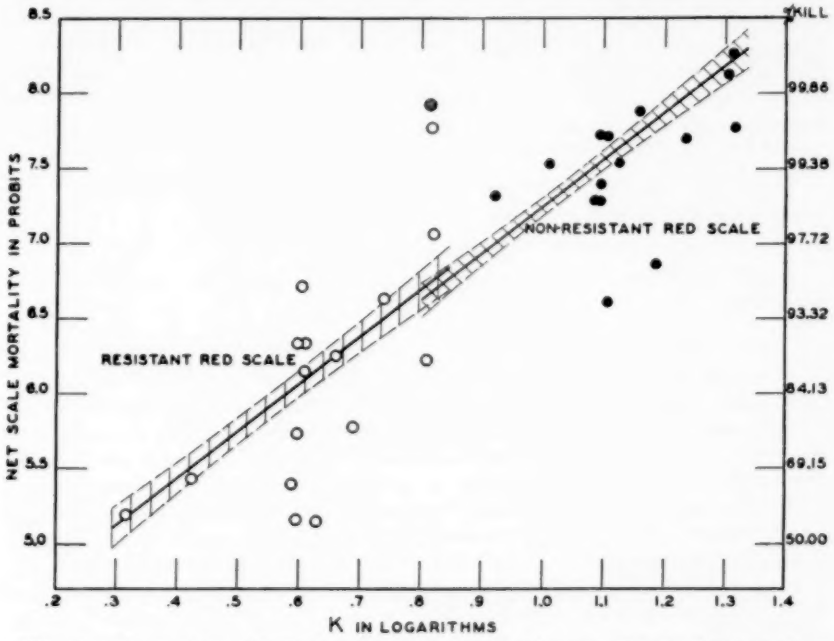

Fig. 5.—Comparison of kills of resistant and non-resistant red scale, fumigated together in the fumatorium. The kills are plotted in probits as a function of log. K. Log. K=log. C+.5 log. T+log. 10 for resistant red scale, and log. K=log. C+.8 log. T+log. 10 for non-resistant red scale. C is the concentration in per cent by volume, T equals the length of exposure in minutes, and the log. 10 is added to make log. K positive values.

These data were analyzed by Dr. Bliss. He found that the two series were nearly enough in agreement to use a single provisional line for both. This line had the formula: $Y = 4.329 + 2.775X$, where X was the log of 10K and Y the probit of the expected mortality. With the weighting coefficients derived from the provisional line and table 3 of the paper by Bliss (*2a*) the regression coefficient for the resistant scale was 3.5747 and for the non-resistant -1.3775. The negative coefficient for the non-resistant scale would indicate that the higher the dosage the smaller the kill. This result was due to the two tests with the lowest concentrations .0309 and .0396, in which a high kill of non-resistant scale was secured at a relatively low dosage, although the kill of resistant scale was as ex-

pected. Because of the large number of scales counted and the relatively large weighting coefficients, these two cases together accounted for 69 per cent of the weights in the non-resistant series and threw the curve "in reverse." When all the observations of the non-resistant series are included, the susceptibility of the non-resistant scale is significantly greater than that of the resistant scale. If these two tests are omitted the slope of the two curves would not have differed significantly.

The curves given in fig. 5 have been based upon the combined regression coefficient for all 16 observations of the resistant scale and 15 of the 16 observations of the non-resistant scale, the fumigation at .0309 concentration being omitted since the number of insects counted gave this test a disproportional weight. The curve is computed from Equation 18 and the variance for the combined slope and for both series was computed from Equation 25 of Bliss (*2b*);

$$Y = 5.9207 + 3.1426(X - .5527) \pm .692\sqrt{.01518 + (X - .5527)^2 .3304}$$

for the resistant, and for the non-resistant the equation is

$$Y = 7.3929 + 3.1426(X - 1.0448) \pm .694\sqrt{.00752 + (X - 1.0448)^2 .3304}$$

On this basis there is no significant difference between the regression lines for the two series.

Influence of Temperature and Relative Humidity upon Kills of Resistant and Non-Resitant Red Scale

In the preceding study of the concentration and the exposure, no weight was given to the effect of the temperature and the relative humidity. The effect of these two factors might be different for the two types of scale.

The average kills obtained in fumigations with the same exposure and approximately the same concentration are grouped under two temperature ranges in table 4.

Table 4.—The influence of temperature upon the kill of resistant and non-resistant red scale treated in the metal fumatorium.

Temp. Range °F	Aver. Kill of Resistant Scale per cent	Aver. Kill of Non-Resistant Scale per cent	Difference in Kill per cent
64–75° F	69.29	99.18	29.89
55–62° F	90.96	98.59	7.63
Diff. in Kill	−21.67	+ .59	

These summaries indicate that the kill of resistant red scale is decidedly lower at the higher temperatures and that of the non-resistant slightly higher.

To examine in detail the effects of temperature and relative humidity two series of tests were selected. One series consisted of 39 tests of non-resistant scale covering a range in concentration of hydrocyanic acid from .00631 per cent to .0984 per cent by volume, the other series of 42 tests of resistant scale represented a range from .0309 per cent to .1048 per cent by volume. All tests were conducted in the fumatorium with an exposure of 45 minutes. Temperatures and relative humidities covered the range of conditions normally encountered in fumigation work.

These data for resistant and non-resistant red scale were plotted separately and the regression lines determined by the method of Bliss (*2a*). This gave the expected kill for each type of insect through the entire range of concentrations. The departure of the observed kills from the expected kill, either + or − was then determined. Considering the expected kills as a line of zero value these departures of actual kill could be plotted in terms of probits, either plus or minus, for the different relative humidities encountered. The line representing the least squares for these departure values was determined for each type of scale. The results indicated that for the resistant red scale the kill was reduced by .9782 probit in passing from 95 per cent to 25 per cent relative humidity and for the non-resistant red scale there was a reduction of .9276 probit.

Table 5.—The lethal constants of three insects recalculated from the data of Brinley & Baker (*3*). Concentration in per cent by volume, exposure in minutes.

Black Chrysanthemum Aphis			Onion Thrips			Granary Weevil		
C	T	$C(T)^{.9}$	C	T	$C(T)^{.5}$	C	T	$C(T)^{\cdot}$
1.0692	.75	.83	.214	.75	.18	7.9965	10	25.3
.6516	1.2	.85	.1167	1.2	.13	6.7500	15	26.1
.3798	2.75	.94	.07785	2.75	.13	4.9140	20	22
.2133	6	1.07	.05386	6	.13	4.5000	30	24.7
.1305	10	1.03	.0486	10	.15			
.0680	15	.78	.0486	15	.19			
.036	30	.71						
.0392	45	1.20						
.0194	60	.77						

These results show a reduction in kill due to the lowering of the relative humidity, which is approximately the same for resistant and non-resistant red scale. These values translated to kills would mean that a concentration of hydrocyanic acid which would give a kill of 99 per cent at a relative humidity of 95 per cent might only be expected to give a kill of 91 per cent to 92 per cent at a relative humidity of 25 per cent.

A similar analysis of the departure values plotted for the temperatures showed that in passing from 50° to 70° F the kill of resistant red scale was reduced .6989 probit but that of the non-resistant red scale rose .174 probit. Rising temperature has a slightly favorable effect on the non-resistant red scale but a decided unfavorable effect on the kill of the resistant red scale.

Converting these values in probits into kills, a concentration of hydrocyanic acid which would kill 99 per cent of resistant scale at 50° F might be expected to give only a 92 per cent kill at 70° F, whereas the dosage of hydrocyanic acid which would give a kill of non-resistant scale of 99 per cent at 50° F might be expected to give a kill of about 99.4 per cent at 70° F.

Discussion.—Considering the data presented, the conclusion is reached that the main differences between the resistant and non-resistant red scale in California is the different reactions of the two types to concentration, exposure, and the temperature at which the fumigation is conducted. The question arises whether these characteristics might have developed as a reaction to hydrocyanic acid fumigations.

The original data of Brinley & Baker (*3*) were re-examined and their results with three insects are given in table 5. Other data obtained by Brinley & Baker indicate a $CT^{.9}$ relationship for *Aphis rumicis* and a CT

relationship for the scale insect *Gymnaspis aechmeae*, Newst. Allison (*1*) and Williams (*10*) found the exposure and concentration of equal value, $K = CT$, for the cockroach.

These results with hydrocyanic acid on various insects indicate that the value of exposure compared to concentration varies from a lethal constant $CT^{.5}$ to a constant of CT. Since some of the species used are not regularly fumigated, it would appear that this characteristic was one of the insect and not due to previous fumigations.

All the above data related to fumigations with hydrocyanic acid. The question arises as to the reactions of insects to other toxic gases. Richardson & Haas (*8*) used the vapor of nicotine and of pyridine to kill *Tribolium*. Their data for a 50 per cent kill indicate a close fit of a lethal constant derived from $C(T)^{.5}$ for both compounds. Another interesting series of tests was reported by Shepard & Lindgren (*9*). With the rice weevil the lethal constant for carbon disulfide was $C(T)^{.5}$, for ethylene dichloride $C(T)^{.7}$, propylene dichloride $C(T)^{.9}$ for 100 per cent kills. When the *Tribolium* was used the lethal constant for carbon disulfide was a good fit at $C(T)^{.9}$ and with both ethylene dichloride and propylene dichloride the factor was $C(T)^{.5}$.

These few illustrations from the literature indicate that the relative importance of exposure and concentration in effecting a kill varies with the insect and the chemical used. This relationship must, at least in some cases, be inherent and not acquired from previous fumigations, since ancestors of many of the insects showing these characteristics have not been previously fumigated with the chemicals toward which they show these reactions.

In entomological literature it is generally considered that the kill improves with an increase in the temperature at which the fumigation is conducted. The results with resistant red scale indicate the opposite effect. An increasing temperature favors chemical and physiological activity, whereas the sorption of a gas by a solid is greater at lower temperatures. Our laboratory experiments now in progress have shown that the sorption of hydrocyanic acid gas at the same pressure and the same exposure may be as much as 30 to 35 per cent greater at 20° C as at 30° C. It is possible that in the case of the resistant red scale the manner in which the hydrocyanic acid gas is taken up by the insect is the controlling factor in effecting a kill, hence the kill is associated with the temperature conditions which favor the sorption of the gas, rather than the temperature conditions which favor the chemical or physiological action of the hydrocyanic acid within the insect. In the case of the non-resistant red scale the kill is improved at higher temperatures, which would indicate that the controlling temperature conditions were those favoring the physiological action of the hydrocyanic acid upon the insect.

In the work of Brinley (*3*) the lethal constant for the black chrysanthemum aphis was .92 at 25° C and .60 at 30° C, showing an increased kill with an increased temperature; but an examination of the data on the onion thrips shows a lethal constant $C(T)^{.5}$ of 13.1 at 20° C and 16.5 at 25° C, a temperature effect similar to that shown by the resistant red scale.

Summary

The results of fumigations of resistant red scale in a metal fumatorium with uniform concentrations of hydrocyanic acid differed from those obtained in orchard fumigations under tents and from those obtained in a form tent.

A series of fumigations of resistant and non-resistant red scale with different concentrations and exposures to hydrocyanic acid developed the following conclusions:

(1) The concentration to which the resistant red scale in California is exposed is of double the value of the length of exposure in effecting a kill, which relationship may be expressed as a constant which is the product of the concentration multiplied by the square root of the length of exposure.

(2) The concentration to which non-resistant red scale in California is exposed is of approximately equal value to the length of exposure in effecting a kill, the lethal constant being the product of the concentration multiplied by the length of exposure to the .8 power.

(3) Increasing the temperature reduces the kill of resistant scale decidedly but slightly improves the kill of non-resistant scale.

(4) Low relative humidities are equally unfavorable and high relative humidities are equally favorable to the kill of resistant and non-resistant red scale.

(5) These different relationships of concentration, exposure and temperature developed as a result of fumigations in a tight fumatorium serve to explain the contradictory results of experiments conducted in a tight fumatorium, and in a tent.

(6) The different relationships of concentration and exposure in producing a kill apparently is not a characteristic acquired from previous fumigation, since other insects not normally fumigated show the same characteristics when fumigated with hydrocyanic acid and even with other chemicals not normally used as fumigants.

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COTTON STATES BRANCH

PAPER-READING SESSION, TENTH ANNUAL MEETING

Atlanta, Ga., January–February 1935

THE BIOLOGICAL POSSIBILITY OF INFESTATION BY FLIGHT OF THE PINK BOLLWORM MOTH

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While collections of insects were being made by airplane in September 1928 at Tlahualilo, Durango, Mexico, pink bollworm moths, *Pectinophora gossypiella* Saund, were taken in the upper air 3000 to 4000 feet above ground. As the elevation in that locality is approximately 3700 feet, the moths were 6700 feet or more above sea level. At the time of collection the temperatures at these elevations averaged about 60° F and there were strong winds blowing from the southeast to the northwest, or toward the United States. These moths must either have voluntarily flown upward or have been carried aloft by the strong convectional air currents which prevail in that section. In either case, once in this stratum of air, the moths were most probably carried with the wind without much resistance. There was the possibility that these moths were dead, or, if alive, that they were so enfeebled by the violence of the air currents that they could not descend to the ground and oviposit. On the other hand, there was the possibility that they might live for several days in the upper air, descend to the ground a long distance from the point of origin of their flight, and still be able to find suitable host plants and lay fertile eggs. In order to secure information on the latter possibility, tests were conducted at Presidio, Tex., during August and September 1931 to determine if fertilized pink bollworm moths could begin or continue to lay fertile eggs after isolation from males and exposure to temperatures similar to those to which they would be subjected in remaining in the air for several days. Females, with few exceptions, have been found to be fertilized within the first 24 hours and to remain fertile throughout their life, although successive matings increase the total number of fertile eggs laid. Immediately after emergence 76 pairs of moths from field-collected larvae were placed in mating cages, five to 10 pairs to a cage. These moths were divided into three series and were subjected to the following treatments:

[1] In cooperation with the Texas Agricultural Experiment Station.

Series 1.—Males with females for first 24 hours. Females isolated from males and cotton bolls and *after* oviposition started placed in ice box at approximately 60° F[2] for one to seven days, then returned to cages at normal temperature for completion of egg deposition.

Series 2.—Males with females for first 24 hours. Females isolated from males and cotton bolls *before* oviposition started and placed in ice box at approximately 60° F[2] for three to seven days, then returned to cages at normal temperature to begin egg deposition.

Series 3.—Checks. Males with females continuously. Both sexes held at normal temperature and oviposition not interrupted.

From four to seven females were used for each period of isolation and seven for the checks. No oviposition occurred while the moths were in the icebox, but moths of both series 1 and 2, after all periods of isolation up to seven days, laid fertile eggs when returned to normal temperatures. The average number of eggs laid by females kept continuously with males in oviposition cages at normal temperature was greater than that of the isolated moths. This is believed to have been largely owing to the effect of successive matings, as there was apparently no correlation between the length of the isolation period and the number of eggs laid. However, the egg-laying records of individual moths differed so widely in all treatments that from the small number of moths used no definite conclusions can be drawn on the effect of isolation. The fertility of the eggs laid by the isolated moths was approximately the same as that of those from the checks. The total life of the moths isolated for part of the time in the ice box was greater than that of the checks kept at normal temperature.

The results of these experiments show that it is biologically possible for fertilized pink bollworm moths to begin or to continue deposition of fertile eggs after as much as seven days' isolation from males and exposure to temperatures comparable to those in the upper air where moths were captured at 6,700 feet above sea level. The conditions of the isolation did not include wind movement, and the results obtained might not be the same for moths carried more or less helplessly along by the wind for corresponding periods. Although the question as to whether the violence of the wind currents in the upper air would render the moths incapable of descending in good condition is still open, these experiments show that if previously fertilized females should descend in good physical condition they would be capable of laying fertile eggs after seven days in the air.

Summary.—Fertilized pink bollworm moths were isolated from males and cotton, and exposed to temperatures comparable to those in which moths were taken in the upper air at Tlahualilo, Durango, Mexico, in September, 1928. After seven days' isolation female moths were able to begin or resume oviposition of fertile eggs.

[2] Temperatures in ice box as recorded by hygro-thermograph ranged from 50 to 70° F with an average of 58°. Average humidity 58.4 per cent.

TWO YEARS' FIELD EXPERIMENTS ON THE CONTROL OF THE COTTON FLEA HOPPER WITH SEVERAL INSECTICIDES

K. P. Ewing and R. L. McGarr, *U. S. D. A., Bureau of Entomology and Plant Quarantine*

During the seasons of 1933 and 1934 a number of tests were made in the vicinity of Port Lavaca, Calhoun county, Tex., to determine the comparative efficacy of sulfur, sodium fluosilicate, a commercial mixture of calcium arsenate and Paris green, and calcium arsenate alone in controlling the cotton flea hopper.

The sulfur used in these experiments was a good grade of yellow dusting sulfur, 99 per cent of which would pass through a 200-mesh screen. The sodium fluosilicate was purchased from a commercial company and was refined especially for dusting purposes. It tested approximately 80 per cent Na_2SiF_6. The calcium-arsenate—Paris-green mixture was a commercial product and consisted of 75 per cent of regular commercial calcium arsenate and 25 per cent of a special "air-floating" Paris green mixed by the wet process. For convenience this will hereafter be referred to as the "mixture."

As, on the whole, the methods of conducting the tests were essentially the same during both years, a description of the tests for only one year will be given, with a brief summary of the results during the other year.

Experiments of 1934

Arrangement of plats.—Three-plat cuts were utilized for each experiment in 1934, each plat containing one acre. Two of the plats were treated for flea hopper control and the third plat left untreated as a check. Nine cuts were selected with due regard to the uniformity of the soil and the cotton in each plat, so that, barring the factor of poisoning, the plats in each cut would be strictly comparable, and the production of cotton from each plat would be the same.

The experiments were so arranged that three cuts compared sulfur, the mixture and the check; two cuts compared sulfur, sodium fluosilicate and the check; two cuts compared the mixture, sodium fluosilicate and the check; one cut compared sulfur, calcium arsenate and the check; and one cut compared the mixture, calcium arsenate and the check.

Poison applications.—The dust applications were made early in the mornings (before 7 a.m.) with one-row hand guns. After the third or fourth application heavy infestation of the cotton aphid developed in each of the plats dusted with the mixture, sodium fluosilicate, or calcium arsenate. Dust applications were suspended on these plats when the cotton aphid infestation developed to such an extent that it was apparent the continued use of the insecticide would be more detrimental by increasing the aphid infestation than beneficial by controlling the flea

[1] Thanks are due Mr. J. B. Pope for valuable assistance rendered in making the field-plat determinations herein recorded.

Table 1.—Applications and dosages of the different insecticides on the field plats of cotton at Port Lavaca, Tex., 1934.

Cut	Date First Application	Sulfur Plats			Mixture Plats			Sodium Fluosilicate Plats			Calcium Arsenate Plats		
		No. applications	Date last application	Av. no. lbs. dust applied per acre	No. applications	Date last application	Av. no. lbs. dust applied per acre	No. applications	Date last application	Av. no. lbs. dust applied per acre	No. applications	Date last application	Av. no. lbs. dust applied per acre
A	5-16	7	6-19	12.29	5	6-19	5.65						
B	5-16	5	6-12	13.40	4	6-6	6.81						
C	5-16	7	6-19	11.89				5	6-7	7.50			
D	5-17	6	6-12	12.67				5	6-7	7.10			
E	5-17				4	6-6	6	3	6-6	7.33			
F	5-17				5	6-22	5.80	5	6-22	6.85		6-6	5.69
G	5-18	5	6-12	12							4	6-6	5.63
H	5-18				4	6-6	5.88				4		
I	5-18	5	6-12	13.90	4	6-6	6.35						
Average		5.8			4.3			4.5			4		
Weighted average				12.62			6.05			7.18			5.66

hoppers. The applications of these insecticides were therefore stopped before the flea hoppers were brought under control, which resulted in some plats in a cut receiving a larger number of applications than others. The mixture plat of Cut A and the sodium fluosilicate plat of Cut C were dusted once with nicotine sulfate for cotton aphid control, but in all other plats the aphid infestation was allowed to run its normal course.

Another factor in the use of the mixture and sodium fluosilicate was the burning of the cotton plant. Both of these insecticides caused burning

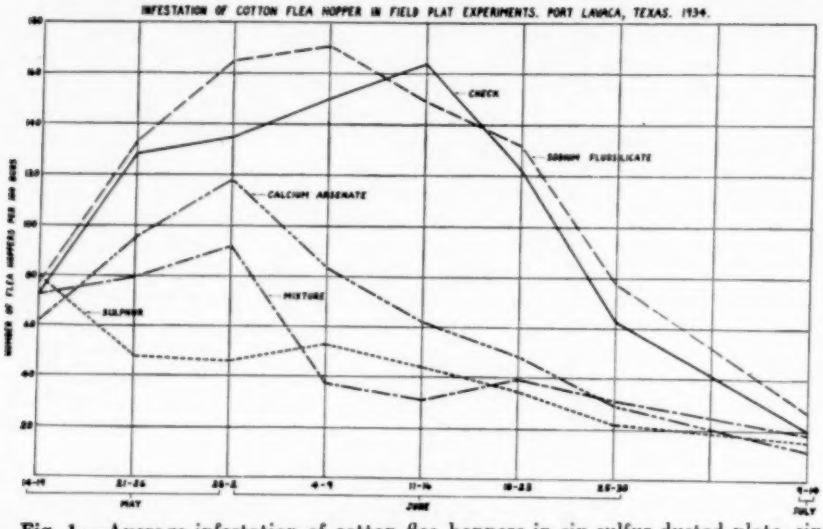

Fig. 1.—Average infestation of cotton flea hoppers in six sulfur-dusted plats, six mixture-dusted plats, four sodium-fluosilicate-dusted plats, two calcium-arsenate-dusted plats and nine check plats during progress of the field-plat experiments, Port Lavaca, Tex., 1934.

when the humidity was extremely high. Burning was more noticeable in 1933, when heavy dews and frequent rains were prevalent, than in 1934, when the weather during the dusting period was comparatively dry.

The dusting was done in general on a five-day schedule. The number and period of the applications and the quantity of dust per acre application are shown in detail and then summarized in table 1. No application was washed off by rain during the season of 1934.

Infestation records.—The flea hopper infestation record was made by inspecting 100 main-stem terminal buds at each of three points in a plat and recording the number of live adults and nymphs. For this record, as well as for all other field-plat records, plants were selected that represented an average of the plat. The first infestation record was made in each cut the day preceding the first dust application, May 15–17, and the succeeding records were made at weekly intervals until the end of June. A last record was made during the period July 9–14.

Approximately 20 per cent of the cotton in Calhoun county was planted early in the season—around the middle of March. A heavy mi-

gration of adult cotton flea hoppers began during the second week of May. These migrating adults concentrated in the early-planted cotton. All experimental cuts were located in cotton of this age; consequently, when the experiments were started the cotton flea hopper infestation was high and was more or less uniform throughout the entire series of plats. Although the experimental cuts were located on widely separated farms, the infestation in the check plats of the various cuts was remarkably uniform at each inspection during the season. A summary of the

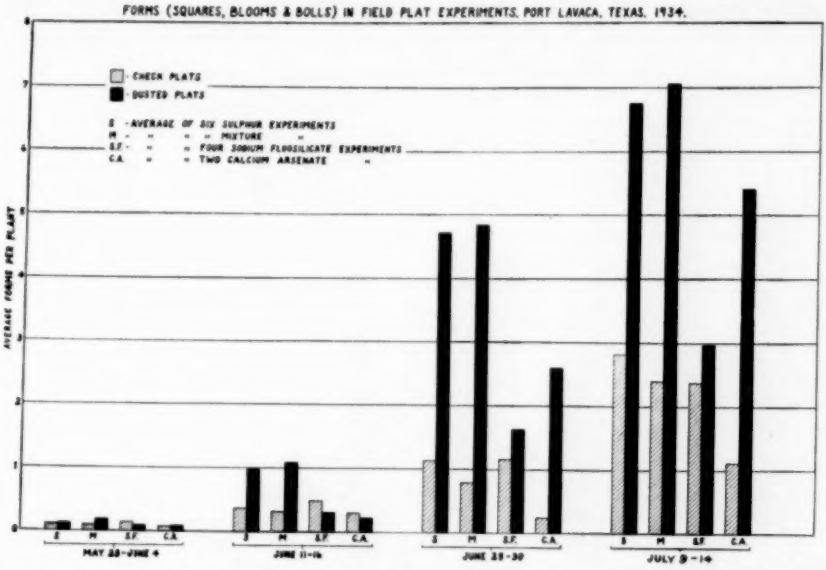

Fig. 2.—Comparison of the number of forms (squares, blooms and bolls) per plant in the treated and untreated plats.

infestation records made in the field plats during 1934 is shown in fig. 1. This chart does not separate the adults from the nymphs. It might be interesting to mention here that the infestation records showed that sulfur gave a much higher kill of nymphs than did the mixture, while the mixture gave a much better kill of adults than the sulfur. For instance, at the time of the second infestation record, which was made two to three days after the second application of dusts and shortly after the first generation of nymphs hatched in cotton, the sulfur plats averaged 32.8 adults and the mixture plats 19.6 adults per 100 buds, while the sulfur plats averaged 14.6 nymphs and the mixture plats 59.7 nymphs per 100 buds.

Boll weevil infestation.—From three to five records of boll weevil infestation were made in each cut during the season, sufficient to determine the status of this insect during the progress of the experiments. The highest infestation in any plat during the season was 11 per cent and the average around 1 per cent, which shows that the presence of the boll

weevil did not influence the results secured by the use of the different insecticides for flea hopper control.

Form counts.—This record consisted in the counts of the number of squares, blooms, and bolls on 300 representative plants per plat—100 plants at each of three points. A summary of these records is shown in fig. 2.

Plant heights.—Six hundred plants, 200 at each of three points in a plat, were measured at more or less regular intervals during the progress of the experiments. Figure 3 is a summary of these records showing the growth of the cotton plants in the different treated and untreated plats.

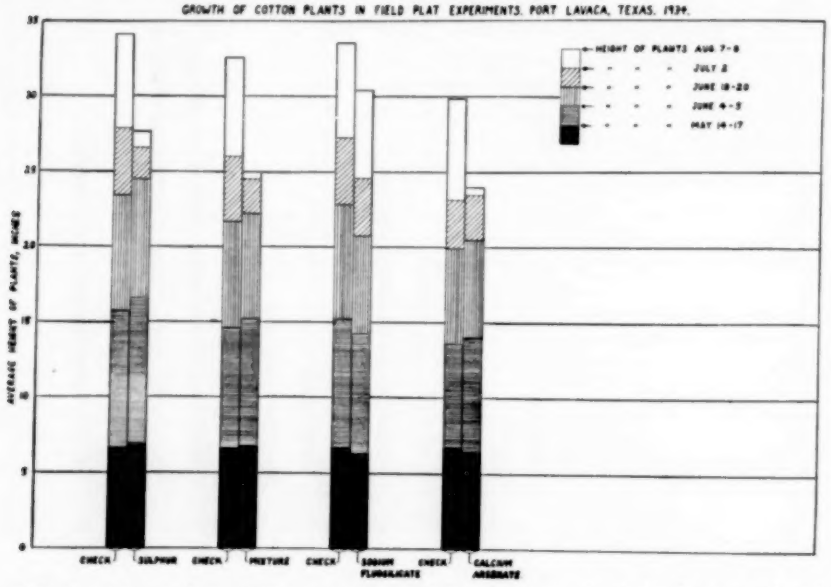

Fig. 3.—Comparison of the growth in height of cotton plants in the treated and untreated plats (average of 600 plants per plat at inspection).

There are times when the cotton flea hopper is so abundant and the injury from the insect is so severe that the growth of the cotton plant is retarded, even though the normal tendency of a cotton plant stripped of its fruit is to grow taller than a plant that is "setting" fruit. Such was the case in 1934, as shown in fig. 3. Throughout the period of the heavy flea hopper infestation, or until June 20, plants in the check plats did not grow quite so tall as did plants in corresponding dusted plats, where the insect was considerably reduced owing to control by the insecticide. However, after the dusted plants had set their crop of fruit the growth in height of these plants practically stopped, while the plants in the check plats, which were almost devoid of fruit, continued to increase in height. This was especially noticeable in the plats dusted with sulfur and the mixture. When the plant-height determinations were made June 18–20,

the plants in the six mixture plats averaged 22.2 inches per plant and those in the six corresponding check plats averaged 21.7 inches. On July 2 the plants in the mixture plats averaged 24.5 inches in height, and in the check plats 26 inches. The measurements made August 7–8 showed the average height of the plants in the mixture plats was 25 inches, an increase in growth of .5 inch since July 2, while the average height of the plants in the check plats was 32.6 inches, an increase of 6.6 inches during the same period.

Table 2.—Summary of bloom counts in field-plat experiments at Port Lavaca' Tex., 1934.

	Average Blooms per Acre								
	July 19–20	June 22	June 25	June 29–30	July 3	July 6	July 9	July 16	July 23
6 Sulfur plats	706	1029	1321	3408	3029	5154	4527	2269	1024
6 Check plats	234	138	160	457	413	1183	1377	1080	698
6 Mixture plats	1273	1515	1466	3701	3822	7526	7225	2361	532
6 Check plats	184	119	134	364	355	1069	1406	1008	806
4 Sodium fluosilicate plats	195	153	240	296	830	2243	2337	744	445
4 Check plats	272	189	211	449	367	958	1367	873	594
2 Calcium arsenate plats	449	402	301	752	2668	7631	7903	3290	909
2 Check plats	62	33	11	29	181	739	1042	965	640

Bloom counts.—All white blooms (blooms less than one day old) on 10 rows in the center of each plat were counted at approximately semi-weekly intervals from June 19 to July 23. This record is a very accurate index of the fruitage of the cotton plant and is one of the best means of showing the direct control of the flea hopper by an insecticide. A summary of the bloom counts is shown in table 2.

Table 3.—Yield of cotton from field-plat experiments at Port Lavaca, Tex., 1934.

	Yield of Seed Cotton per Acre					[Increase in Yield Over Check							
		Pounds				Pounds				Per Cent			
Cut	Check	Sulfur	Mixture	Sodium fluosilicate	Calcium arsenate	Sulfur	Mixture	Sodium fluosilicate	Calcium arsenate	Sulfur	Mixture	Sodium fluosilicate	Calcium arsenate
A	66	456	477			390	411			590.9	622.7		
B	172	418	542			246	370			143	215.1		
C	292	590		294		298		2		102.1		.7	
D	208	514		246		306		38		147.1		18.3	
E	180		500	220			320	40			177.8	22.2	
F	38		312	40			274	2			721.1	5.3	
G	54	318			256	264			202	488.9			374.1
H	40		244		198		204		158		510		395
I	264	596	528			332	264			125.8	100		
Average		482	434	200	227	306	307	20	180	173.9	242.5	11.4	383

Yield of cotton.—Yield records were secured from one-half acre in each plat, a portion of the 20 center rows being usually selected. From two to three pickings were made from this part of each plat, and the amount of seed cotton produced at each picking was carefully weighed.

Table 3 shows the yield of cotton from the treated and untreated plats in each experimental cut and the increase, by pounds and percentages, in the dusted plats over their corresponding check plats. It will be noted that the difference in the increased yields in the sulfur and mixture-dusted plats, 306 and 307 pounds respectively, is negligible.

In the case of the three experiments in which direct comparisons of

Table 4.—Applications of dust and yield of seed cotton from field-plat experiments at Port Lavaca, Tex., 1933.

Cut	Total No. Applications	No. Effective Applications[2]	Date First Application	Date Last Application	Average No. Lbs. Applied per Acre			Yield per Acre of Seed Cotton, Pounds				Increase in Yield over Check					
					Sulfur	Sodium fluosilicate	Mixture	Check	Sulfur	Sodium fluosilicate	Mixture	Sulfur		Sodium fluosilicate		Mixture	
												Pounds	*Per cent*	*Pounds*	*Per cent*	*Pounds*	*Per cent*
A	4	4	5-16	6-17	11.56			724	874			150	20.7				
B	5	5	5-16	6-17	11.95			592	944			352	59.5				
C	5	4	5-18	6-17	12.35			498	822			324	65.1				
D	5	5	5-27	6-28	12.95			693	860			167	24.1				
E	5	4	6-7	7-10	12.70	11.20		618	856	772		238	38.5	154	24.9		
F	3	2	6-7	6-19	11.67			1050	1194			144	13.7				
G	6	4	6-8	7-8	12.83	10.79		606	974	802		368	60.7	196	32.3		
H	6	4	6-8	7-8	12.29	10.54		1252	1384	1206		132	10.5	−46	−3.8		
I	6	4	6-10	8-19		10.25	8.08	422		522	546			100	23.7	124	29.4
J	5	4	6-20	7-15	13.70		7.80	923	1334		1112	411	44.5			189	20.5
K	5	3	6-24	8-19	11.80		8.10	410	570		516	160	39			106	25.9
L	4	4	6-24	8-19	10.75		7.75	172	260		324	88	51.2			152	88.4
M	7	6	7-7	8-18			6.36	766			1070					304	39.9
N	7	6	7-7	8-18			5.89	964			960					−4	− .4
Average									915.6	825.5	754.7	230.4	33.6	101	13.9	145.2	23.8
Weighted average					12.3	10.7	7.2										

[2] Applications washed off by rain within 24 hours after dusting were not considered effective.

sulfur and mixture were made, Cuts A, B and I, the average yield per acre was as follows: check plats 167.3 pounds, sulfur-dusted plats 490 pounds, mixture-dusted plats 515.7 pounds. The three mixture-dusted plats produced an average of 348.4 pounds, or 208.2 per cent, more than the three check plats; and the three sulfur-dusted plats produced 322.7 pounds, or 192.9 per cent, more than the check plats.

Sodium fluosilicate proved of no practical value as a control of the cotton flea hopper. The increase in the yield of seed cotton in the four plats dusted with this insecticide averaged 20 pounds per acre, 11.4 per

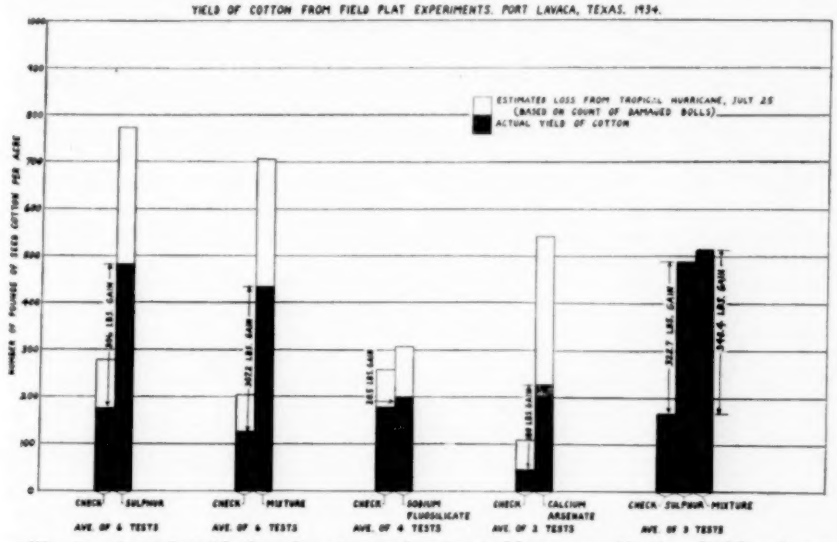
YIELD OF COTTON FROM FIELD PLAT EXPERIMENTS. PORT LAVACA, TEXAS. 1934.
ESTIMATED LOSS FROM TROPICAL HURRICANE, JULY 25 (BASED ON COUNT OF DAMAGED BOLLS)
ACTUAL YIELD OF COTTON
NUMBER OF POUNDS OF SEED COTTON PER ACRE
CHECK
SULPHUR
MIXTURE
SODIUM FLUOSILICATE
CALCIUM ARSENATE
AVE. OF 4 TESTS
AVE. OF 3 TESTS

Fig. 4.—Actual yield of seed cotton and estimated loss caused by tropical hurricane July 25, in the different treated and the untreated plats.

cent more than the corresponding check plats. The value of this increased yield was not sufficient to pay the cost of the dusting operations.

The preliminary tests with calcium arsenate showed that this insecticide was of some value in controlling the cotton flea hopper, but that it was not so effective as either sulfur or the mixture, the average increase from the use of calcium arsenate being 180 pounds per acre.

Effects of the tropical hurricane.—Inspections in September of the open bolls and the bolls that did not open as a result of injury from the tropical hurricane on July 25, 1934, showed that the damaged bolls (bolls that were a total loss) ranged from a minimum of 25.7 per cent to a maximum of 59.4 per cent in the different experimental cuts, with an average of 40.8 per cent per field. The estimated damage in the sulfur plats averaged 37.6 per cent and in the mixture plats 38.9 per cent. The estimated loss in the check or untreated plats was 84.2 pounds of seed cotton per acre, in the sulfur plats 290.8 pounds, in the mixture plats 272.9 pounds, and in the sodium fluosilicate plats 108.3 pounds. There

were no bolls produced on the cotton in any of the experimental cuts after the hurricane. Figure 4 shows the actual production and an estimate of what the production of cotton would have been without the hurricane, from the different field tests of 1934.

Field-plat Experiments During 1933

Thirty-five one-acre plats were utilized in 1933, divided as follows: 11 plats were dusted with sulfur, six with the mixture, four with sodium fluosilicate, and 14 were left untreated as checks. There were seven two-plat cuts and seven three-plat cuts. All of the two-plat sulfur cuts except one were started early in the season, between May 16 and 27.

The 11 sulfur tests of 1933 were conducted under widely different conditions, that is, the time of starting the experiments ranged from May 16 to June 24, the infestation in the different plats ranged from light to heavy, and the number of effective applications ranged from two to five per plat.

Table 4 shows the dates of the first and last dust applications on each cut, the total number of applications, and the number of effective applications made on each cut, the dosage of each insecticide per plat, and the yield of cotton from the various plats.

Summary

Sixty-two field-plat tests were made during 1933 and 1934 to determine the comparative efficacy of sulfur, sodium fluosilicate, a commercial mixture of 75 per cent calcium arsenate and 25 per cent Paris green, and calcium arsenate alone in controlling the cotton flea hopper. The infestation records and a count of the squares, blooms and bolls on cotton plants in the treated and untreated plats during the progress of the experiments, as well as the final yield of cotton from the various plats, showed that sulfur and the mixture of calcium arsenate and Paris green were effective in controlling the cotton flea hopper. Only two preliminary tests were made with calcium arsenate; these were in 1934 and showed fair results. The field tests showed that sodium fluosilicate was ineffective in controlling this insect.

REPORT ON COTTON LEAF-WORM INVESTIGATIONS IN FLORIDA, INCLUDING TEMPERATURE AND HIBERNATION STUDIES

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Nature of injury and economic importance.—At one time this species was the most important and destructive enemy of the cotton plant in America. Some idea of its economic importance, during the latter part

of the nineteenth century, may be gained from the following statement written by Riley (*4*).

> A calculation of the money losses which the cotton worm inflicts on the people of the South leads to the following interesting conclusions. In years of severe injury, from 30 to 98 per cent of the crop may be ruined upon some plantations, while on others the loss will be trifling. The highest average loss is sustained in the southern portion of the belt, as in Florida and southern Texas. It increases also in a westerly direction, commencing with Georgia at 16 per cent, or 16 bales out of every 100, and ending with Texas at 28 per cent. There is a possible loss, in years of great prevalence, of about $30,000,000. On this basis the average annual loss may safely be put down at about $15,000,000 for the cotton states.

Now let us advance along the road of time, forty-six years, to the year 1931. Here we find Sanderson & Peairs (*5*) making the following statement concerning this species: "Once the most important pest of cotton, this insect, since the advent of the boll weevil and the changed conditions brought about by it, has been relegated to a minor position."

The writer also considers this a minor pest, at the present; but keenly appreciates the great destructive ability of the species, should conditions change or should the insect transfer to other hosts.

Host plants.—The attack of *Alabama argillacea* is centered upon the cotton plant. At the present time American entomologists recognize only one host plant for this species. On cotton the larvae are heavy feeders, especially during the mature larval stadia. They consume vast quantities of leaf tissue and often completely defoliate the plants; sometimes eating the stems also. They are usually held in check by the calcium arsenate dust which is applied for the boll weevil.

Cotton belongs to the mallow family, or Malvaceae, which has representatives in nearly all parts of the world, but its species are most abundant in the tropics and in warm regions. Several plants of economic importance are included in the family. In addition to cotton, or *Gossypium*, which is the most important, we may mention the Deccan hemp *Hibiscus cannibinus;* okra, *H. exulentus;* mallow, *Malva sylvestris;* and marshmallow, *Althaea officinalis*. None of these plants are attacked. A closely related species, the okra or mallow caterpillar, attacks several members of this family.

The genus *Gossypium*, to which cotton belongs, contains numerous species. Authorities disagree concerning the number. At the present time twenty-nine species are recognized. The adult females of *Alabama argillacea* do not show any marked varietal oviposition preference.

In some of the tropical countries to the south of us, other plants have been reported as hosts of the larvae. In Colombia it was reported that the larvae were found in most plantations of tobacco, cotton, maize and tomatoes. They were eating the young tender leaves and flowers (*2*). E. G. Smyth (*6*) published an article in Entomological News in which he claimed that this species was controlled by the destruction of the alternate hosts. These alternate hosts were *Urena lobata* and *Malachra ro-*

tundifolia. In 1919, G. Guedes (*3*) claimed that the coffee plants were injured in Sao Paulo. Condara reported a possible attack on maize in Mexico.

The imagines feed upon the sweet exudations from the glands of the cotton plant, as well as the exudations of other plants. The moths also feed upon various fruits, such as figs, plums, peaches, apples, apricots, grapes, persimmons, tomatoes, and sometimes melons. The proboscis is clothed on the dorsal side of its distal extremity with numerous stout and sharp spines, which are thicker near the tip. It is by use of the spiny proboscis that the adult moth works a hole in these fruits, then feeds upon the contents. The mouth parts are inserted deep into the tissue and cause the surrounding tissue to turn darker and rotting to set in.

Life history and habits.—Like all noctuid moths, the habits are rather difficult to observe. If molested during the day they make quick darting flights and hurriedly conceal themselves beneath the leaves. At dusk they may be observed flying leisurely about seeking food or preparing for the act of copulation. The actual act of copulation has never been observed by the writer. It undoubtedly occurs at night, and is never continued after the break of day.

The adult female may deposit eggs three days after dehiscence from the pupal case. Oviposition may continue for 15 days. The length of time between emergence and copulation has never been definitely determined.

The eggs are deposited preferably upon the lower surface of the leaves. They are laid singly and the secretion from the colleteral glands is used in sticking the small greenish blue egg to the surface. This species has a marvelous power of reproduction. If it were not for parasitic and predacious enemies that attack it during the early generations, it would likely wipe out the cotton industry in most cotton producing areas. Tests were conducted concerning prolificacy. One female moth confined in a glass container deposited a total of 1301 eggs. This deposition was completed over a period of 12 days. The moth died on the last day of oviposition.

The length of the incubation period is influenced by the existing temperature and humidity. A high humidity and temperature favor the embryological development and hatching of the young caterpillar. The average length of time required for this stage is three and a half days.

The number of larval stadia varies. The author found that some of the larvae had only five stadia, while others had six. Riley (*4*) stated that during the summer the species might have only four stadia. The writer never observed this.

The length of the larval instar varies, depending upon the existing temperature and humidity. The maximum length of time required was 20 days, the minimum length of time required was 12 days, and the average was 15.4 days.

When the caterpillars reach larval maturity they prepare a pupation shelter. This is usually a folded leaf. The leaf is drawn together by the use of cephalic silk. This makeshift cocoon is not very resistant to the enemies of the cotton leaf-worm pupae. Various kinds of predacious in-

sects and other animals can gain admittance and then destroy the chrysalis. After the covering has been prepared, the body of the larva begins shrinking and becomes much lighter. Usually within twenty-four hours a split appears in the cephalic part of the larval skin, on the dorsal side, and the pupa works its way out.

When first formed the pupa is light green. In an hour or slightly longer, it acquires first a reddish brown and then a distinct brown color. Near the end of the pupal stage it becomes deep brown, almost black. The length of this instar is governed largely by the existing temperature and humidity. The maximum length of time spent in the stage was 12 days; the minimum was eight days; and the average was 8.8 days.

Hibernation.—There has always been a great difference of opinion, among the growers as well as entomologists, concerning the hibernation of this species. There are supporters of three different theories concerning hibernation. First, numerous people believe that the hibernating stage of *Alabama argillacea* is the chrysalis. Many farmers throughout the southern states believe that they have plowed this stage of the insect, during the winter months. The writer's experiments concerning this species indicate that this theory is absurd. Many pupae and larvae were placed on or under the surface of the soil during October. When the temperature went below 40° F and remained there for a short time, all of the insects were killed. There are numerous species that closely resemble the cotton leaf-worm in the pupal instar, and they have undoubtedly been confused with this species. Secondly, many growers and numerous recognized entomologists believe that the species hibernates as an imagine, in some of the southernmost cotton producing states. Large numbers of growers have reported the presence of the adult in various situations, during the winter months. Some have stated that they observed the moths flying during the milder weather of winter and spring. Quite a bit of the information concerning the hibernating adult has been supplied by inexperienced farmers. However some of those reporting the occurrence of the hibernating moth should have seen the adult on enough occasions to prevent misidentification. Some rather well-recognized entomological observers have reported the occurrence of the hibernating moth as late as March. Riley (*4*), who has done the most extensive work upon this species, emphatically stated in 1885, that the moth was the hibernating stage. Thirdly, many scientific investigators believe that there does not exist a hibernating stage in this country; and that the insect dies out in November or December and reappears in March, April and May. They believe that the annual appearance of the insect is due to the migratory habits of the imagines; and that they fly into the states from some of the countries to the south of us. Some of the workers believe this species to be a native of the West Indies and South America. Until recently the writer was in doubt concerning the presence of this insect in the West Indian islands, from December to April. This was due to the fact that Andre Audant, a cotton insect specialist, stated that it was only present in Haiti from late April, early May until early December. However, Mr. Audant (*1*) has recently sent me a paper in which he claims to have observed the insect throughout the winter

months. Abnormal weather conditions that year may explain the presence of the species in Haiti throughout the winter. From the observations made and the data accumulated, the writer is forced to believe that the native home of this species is South America. The appearance in the West Indian islands in May and subsequently in the states is undoubtedly due to the migratory spirit of the imagines. They are active fliers. Ordinarily, they fly around in the fields with a fast, darting flight. As soon as they light, they hurriedly conceal themselves. When the infestation becomes heavy and the weather conditions are suitable their type of flight may change markedly. Numbers of the later generations may be observed, during cloudy and windy days, rapidly flying straight up into the air. At this time they ascend high into the air and are carried considerable distances by the prevailing winds. In the fall the adults have been collected in the northwestern states, the northeastern states and Canada. There is not a host plant of *Alabama argillacea* larvae in these districts. The adults feed upon fruits. These migratory adults die without ever depositing their eggs; a striking example of the sacrifice of imagines upon the altar of the migratory stimulus. These facts are all submitted in support of the writer's belief that this is a South American migratory species, that appears annually.

Seasonal cycle.—The exact seasonal cycle of this species in the United States apparently depends upon the location. The time of the appearance of the first brood is a much debated question. Riley was a firm believer in "the moth hibernating theory." He believed that the moths sought concealment during the cold months of winter and reappeared during the spring. In the fourth report of the Entomologist, published in 1885 (*4*), he stated that the caterpillars had been observed during the month of March in Florida.

The investigations conducted by the writer tend to support the theory that this is a migratory species and the time of its appearance in any locality will depend upon its location. The southern states would receive the first influx of tropical visitors. Then as the season progresses, they would gradually migrate to the more northern cotton producing states; finally the moths would attack various fruit crops. If the migratory theory is correct, the number of broods annually will be partially determined by the prevailing winds. In Florida there are probably five to eight broods during the year.

Temperature studies.[1]—Seventeen unmated males and females were subjected to low temperatures. The maximum length of life of the males was five days. The minimum was one day. The maximum length of life of the females was six days. The minimum was two days. Twelve mated males and females were subjected to the same temperature conditions. The maximum life of the males was four days, of the females three days. The minimum length of life of the males and the females was one day. The results indicate that the unmated individuals are better able to withstand cool weather than are the mated individuals. It also tends to disprove the theory concerning the hibernation of the moth in the southern states.

[1] All tests conducted in a Frigidaire at a constant temperature of 7–9° C.

Forty-seven groups of eggs, each containing twenty eggs, were subjected to Frigidaire temperatures for varying lengths of time. Checks were run at room temperature and all of them hatched in three days. Some of the groups that were subjected to low temperatures were removed to room temperatures for varying lengths of time and then resubjected. The temperature of the Frigidaire varied between 48° and 50° F. Under this condition no eggs hatched that were subjected longer than four days.

Twenty-two larvae in the second stadium were subjected to Frigidaire temperatures. They were allowed to remain for one to twenty-two days. The only larvae to reach maturity and pupate, after removal, were those that were subjected for only one day. The adults emerging from these pupae were usually deformed. Larvae subjected for two days failed to feed after removal to normal room conditions. All individuals subjected three or more days were dead upon removal to laboratory conditions.

Twenty-five larvae in the fifth stadium were subjected to low temperatures. They were allowed to remain from one to twenty-five days, then removed to normal room temperature and placed upon fresh cotton leaves. The larve subjected for one day lived for seven days after removal from the Frigidaire, but failed to consume food. Larvae subjected two to seven days were dead upon removal. The larva subjected for eight days lived two days after removal, but did not consume food. The larvae subjected for nine to twenty-five days were dead upon removal to laboratory conditions.

Fifteen larvae in the prepupal stage were subjected to low temperature conditions. They were allowed to remain for one to fifteen days, then removed to room conditions. The prepupae, subjected for one and two days, pupated after one day at laboratory conditions, but the adult insects failed to emerge. Those specimens subjected for three to fifteen days were dead upon removal.

Twenty-eight pupae were subjected to low temperatures the day of pupation. They were allowed to remain for one to twenty-eight days, then removed to normal laboratory conditions. The pupae subjected for one to ten days emerged after removal to the laboratory. In each case the pupal stage was increased by the number of days that the specimen was held at low temperatures. The pupae subjected for eleven to twenty-eight days were dead upon removal to laboratory conditions.

The above temperature results indicate very clearly the unfeasibility of hibernation of this species, in any stage, in the United States. It tends to substantiate the migratory theory and to prove that the native home of this species is South America. Annual reinfestation in the cotton states in unquestionably due to spring migratory females.

Parasites and predators.—Numerous parasites have been recorded as preying upon this species. The writer reared the following from Florida collected material: 1. *Brachymeria ovata* Say, 2. *Syntomosphyrum esurus* Riley, 3. *Sarphaga lambens* Wd., 4. *Beskia aelops* Walker, 5. *Megaselia scalaris* Liv., and 6. *Pulecephora* sp. These species, in so far as the author was able to determine, have never been reported as parasites of *Alabama argillacea* Hub.

Many predators have been reported attacking the cotton leaf-worm. The following were observed by the writer and have never been reported before: (1) *Podisus maculiventris* Say, (2) *Zelus bilobus* Fabr., (3) *Dysdercus suturellus* Herrich-Schaffer, (4) *Nezara viridula* Linn., and (5) *Allograpta obliqua* Say.

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OCCURRENCE OF *APHIS MEDICAGINIS* KOCH AND *ANOMIS FLAVA FIMBRIAGO* STEPH. ON COTTON IN SOUTH CAROLINA

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Aphis medicaginis Koch, known as the cowpea aphid, was present in injurious numbers on seedling cotton during the spring of 1934 in South Carolina. It made its appearance before much of the cotton was chopped, and the injury caused by it was especially noticeable between the chopping period and the appearance of the first squares. The attack was centralized in the terminal buds and on the small leaflets and petioles. It was very seldom found on the larger leaves, differing in this respect from the cotton aphid, *Aphis gossypii* Glov.

The ordinary observer is inclined to suspect all aphid injury to the cotton plant above ground as being caused by the cotton aphid, and practically all reports of aphids on cotton refer to this species when, no doubt, some other species is at times responsible for the damage. One typical instance is cited. Early in the spring of 1933 a severe outbreak of aphids on seedling cotton was reported near Florence, S. C. Investigations were made and it was found that the entire field of cotton was practically killed. Although this damage was attributed to the cotton aphid *A. gossypii*, no positive determinations were made, and the writer, judging from his investigations in the spring of 1934, is inclined to believe that this injury was caused by the cowpea aphid *A. medicaginis*. The observations made in 1934 prove conclusively that *A. medicaginis* is at times an important insect pest of cotton. It was widely distributed over the eastern part of South Carolina in the spring of that year, some injury being observed in each of the following counties: Florence, Darlington, Marion, Williamsburg, Dorchester, Charleston, Beaufort and Colleton.

In appearance the viviparae of *A. medicaginis* are larger and darker than those of *A. gossypii*. The following descriptions are quoted from Gillette & Palmer (*1*):

> A. MEDICAGINIS. *Color.*—Black on entire dorsum, polished in adults, dull and pulverulent with slaty grayish tint in nymphs, pale grayish green in new-born young; cornicles and cauda black; legs and antennae whitish. *Measurements.*—Apterous viviparae, body 1.6–1.9 mm.
>
> A. GOSSYPII. *Color.*—Viviparae, pale yellow to pale sordid or yellowish green to mottled blackish green without dusky markings, except on lateral areas; legs pale; cornicles black; nymphs of alatae green with dorsum of abdomen flesh color, powdered on head and thorax and usually tesselated on abdomen. *Measurements.*—Apterous summer vivipara, body to base of cauda 1.1–1.8 mm.

Anomis flava fimbriago Steph.—The larvae of this noctuid caused some injury to the leaves and occasionally to the squares of cotton during the summer and fall of 1934 in South Carlina. It is known to attack a number of Malvaceae, but there are few records of its attack on cotton. However, this is probably due to the fact that its damage is attributed to some other insect, particularly to *Alabama argillacea* Hbn., and perhaps less frequently to *Anomis erosa* Hbn. The larvae were found feeding in cotton squares the last week of August, and pupae were found webbed up in cotton leaves the latter part of September and through October.

There was a heavy infestation of cotton leaf worms, *A. argillacea*, in South Carolina during the fall of 1934. Pupae were collected from the cotton leaves and placed in cages to obtain parasite records and to get good specimens of moths. On several occasions moths other than *A. argillacea* emerged from these pupae. Moths similar to these had been reared from cotton squares and had been determined by F. H. Benjamin as *A. flava fimbriago*. After observing that these moths frequently emerged from pupae thought to be *A. argillacea*, it was decided to find out what percentage of the emergence was *A. argillacea* and what percentage was *A. flava fimbriago*. Consequently, 100 pupae were collected at random from cotton leaves and placed in a cage. Each pupa was superficially examined, and they all appeared to be the same. From these 100 pupae, 64 *A. argillacea* and five *A. flava fimbriago* emerged. Of the total emergence, therefore, 7.2 per cent belonged to the latter species. As has been stated, the pupae all appeared to be the same, and no difference was observed in the larvae feeding in the field. All of the damage was being attributed to *A. argillacea*, when as a matter of fact, *A. flava fimbriago* might have been responsible for part of the damage.

The adults of *Anomis flava fimbriago* and *Anomis erosa*, the two most commonly found on Malvaceae in the south, are not often confused with those of *Alabama argillacea*, but the larvae are frequently confused, as their external appearances are similar. The newly hatched larvae are especially hard to distinguish by the field worker. However, Riley (*2*) has pointed out a distinguishing character that will always separate these two species of *Anomis* from *Alabama argillacea:* in the first instar in the

newly hatched larvae of *fimbriago* and *erosa* there are but three pairs of prolegs, while in *Alabama argillacea* there are four, although the first pair is much reduced in size. The full-grown larvae of these two species of *Anomis* have four pairs of prolegs, the first pair being somewhat smaller than the other three. The full-grown larvae of *Alabama argillacea* have five pairs of prolegs, the first pair being much reduced. The anal pair of prolegs is considered as the fourth pair in *Anomis* and the fifth pair in *Alabama*. Thus without much trouble one can place the larvae of these three species in their respective genera. But the larval characters of *A. erosa* and *A. flava fimbriago* are not known as being distinguishable from each other, so that attempts to separate the two in the field at the present time would be futile.

The adults of the two species of *Anomis* discussed above are very frequently confused. *A. flava fimbriago* is strongly sexually dimorphic, the females very closely resembling *A. erosa*, which is only slightly sexually dimorphic. Thus it is rather difficult to separate the two species with certainty. The tendency is to consider all females of *fimbriago* as *erosa*, and to consider as *fimbriago* only the males of that species.

Literature Cited

(*1*) Gillete, C. P. and M. A. Palmer. 1932. The aphidae of Colorado, part 2. Ann. Ent. Soc. Amer. **25** (2): 369–496.
(*2*) Riley, C. V. 1885. Fourth Rep. Ent. Comm., U. S. D. A., p. 347.

DISTRIBUTION OF HIBERNATED BOLL WEEVILS IN AN OKLAHOMA COTTON FIELD

Ephriam Hixson, *Oklahoma A. and M. College, Stillwater*

In past years, it has been very noticeable that the first boll weevils found in cotton fields in the spring were on the largest plants. With this in mind, it was decided to grow some early cotton in a greenhouse, and later to transplant the seedlings in a cotton field to see if they were more attractive than the smaller field plants and could therefore be used as a trap crop. The field selected was one in McCurtain county near Idabel, Okla., in the extreme southeastern corner of the state. According to previous records the chances were very good that this field would have a large weevil population. The soil was very fertile and the field was close to woods in which weevils could hibernate. There also had been a very mild winter which was favorable for a large number of weevils to survive. The rows of cotton were 660 feet long, extending in a north-south direction, parallel with heavy woods situated about forty feet to the west. Between these woods and the cotton was a very weedy fence row. The location of the field with reference to surrounding crops and woods is shown in fig. 1.

The greenhouse plants were grown to about six inches in height with

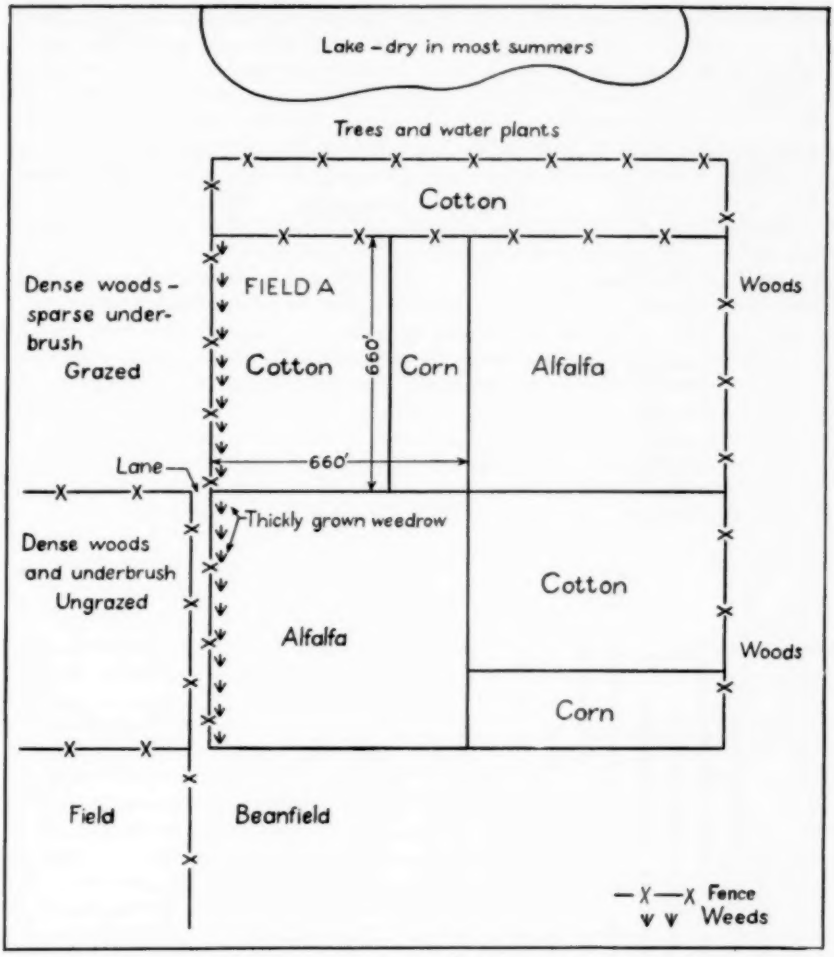

Fig. 1.—Diagram of the area surrounding field A in which the study was made, showing location of adjacent crops and woods.

six leaves. They were set out in the field May 15, 1934. The first plant was set out in the fifth row from the edge of the field on the side nearest the woods, 30 feet from the south end. One plant was then set out every 30 feet until there were 20 transplants in this row, the last one being 30 feet from the north end. In a like manner 20 transplants were set out in every fifth row thereafter across the field until there were 12 rows with a total of 240 transplants, distributed in an area of about three acres.

Each transplant and the 12 or 13 field plants on each side of it constituted a point which was identified by a numbered stake. These plants were examined May 21, 24, 28, 31, June 4, 8 and 12, for the presence of

boll weevils. This made a total of 25 field plants examined near each stake or point, totaling 500 per row or 6000 for the field, exclusive of the transplants. The bud, upper and lower leaf surfaces on each plant were examined and the weevils recorded were left undisturbed if possible. No effort was made to determine if the same weevils were present at the same point at each examination, but it was noticeable that points having weevils at one examination did not always have them at the one following.

The transplants will not be considered further in this discussion since due to the total absence of rainfall during May and June they began dying soon after being set out. None of them grew, although many lived; and only two weevils were collected from the 240 transplants in the seven examinations. Although the death or lack of growth of the transplants defeated the original purpose of the experiment, the frequent examinations of the other plants at each point gave information on the distribution of overwintered boll weevils in this field and the possible relationship of this to nearby hibernation places.

A total of 137 weevils were counted on the 6000 plants May 21, while 136 were found at the next examination which was made on May 24. The total increased quite rapidly up to 272, the number counted on June 8. This was the peak, for a smaller number was counted June 12, the date of the last examination. These figures indicate that weevils were continuing to enter the fields from hibernation at least as late as June 8.

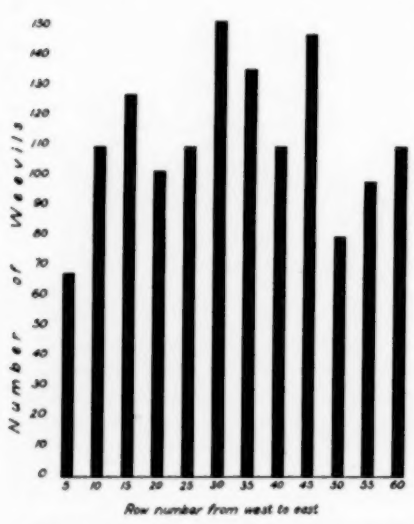

Fig. 2.—Total number of weevils found on 500 stalks of cotton in each of 12 rows.

It was found in this particular field that weevil distribution was not influenced by proximity to the woods situated to the west. The total number of weevils found on each count row showed no concentration on plants nearest the woods. This fact is brought out in fig. 2, which shows the total number of weevils recorded from 20 points in each count row for the seven examinations. Note that row 5, which was nearest the woods and fence row, had the smallest number of weevils, while rows 30 and 45 near the center and opposite side of the field had the greatest number. Row 5 did not have the largest number of weevils at any count date, in fact its best rank was tie for eighth place out of twelve. Only once in the seven examinations did the maximum number of weevils occur closer to the woods than row 30 and that was on June 12. The total number of weevils counted on any one row for any given date ranged

from four as recorded on row 20 on May 21; to 29, the total counted on rows 30 and 15, on May 31 and June 12 respectively.

A study of the weevil distribution by points for each examination date showed an apparent concentration nearest the alfalfa field. A correlation study of the weevil population at the given points on each date of examination was made to determine if there actually were a concentration nearest the alfalfa field. For the examination of May 21, the coefficient of correlation between the increase in the distance from alfalfa and decrease in the weevil population was found to be $-.004$, in other words there was no correlation present. May 24, r was found to be $-.135$ which showed very little correlation between the two factors, however analysis of distribution data of later dates showed that the weevil population tended to concentrate nearest the alfalfa from this date. The value of r for May 28, 31, June 4 was $-.221$, $-.506$, $-.591$ respectively.

This indicates a decided correlation which increased in each examination. The value of r dropped to $-.470$ and $-.412$ on June 8 and 12 respectively. Since weevils were continuing to enter the field up to and including June 4, the increases in the correlation up to this date are highly significant. Although the peak in field population was recorded June 8, a part of the decrease in the value of the coefficient of correlation on the last two dates can partly be accounted for by the tendency of the weevil population to disperse evenly over the field. This dispersion would tend to mask the concentration nearest the alfalfa field.

The coefficient of correlation for the complete records was $-.566 \pm .152$, the latter figure being the standard error. An analysis of the two factors on the basis of a moving three-point average to correct field variation was $-.70 \pm .12$.

From the above facts, it is concluded that there was a definite concentration of boll weevils in that part of the field nearest the alfalfa and that this tended to increase, as the later examinations showed. Whether the weevils were coming from the alfalfa or some point beyond is not known.

Summary.—Distribution of overwintered boll weevils in a heavily infested cotton field in southeastern Oklahoma in late May and early June 1934 showed no relationship to nearness of adjacent woods. The weevils did, however, tend to be more numerous in that part of the field nearest the alfalfa and this tendency increased noticeably in the later examinations. Statistical analysis showed a high degree of negative correlation between weevil population and increase in distance from the alfalfa field.

PERCENTAGE AND CAUSES OF MORTALITY OF BOLL WEEVIL STAGES WITHIN THE SQUARES

G. L. SMITH, *U. S. D. A., Bureau of Entomology and Plant Quarantine*

During the cotton fruiting seasons of 1929 to 1932, inclusive, collections of fallen and hanging cotton squares were made at approximately 15-day intervals during June, July and August, from eight fields in

Table 1.—Summary of square examinations for boll weevil stages for the years 1929, 1930, 1931 and 1932, Tallulah, La.

Date	Hanging Squares							Fallen Squares						
	Total squares collected	Percentage of stages		Percentage of mortality distributed by causes				Total squares collected	Percentage of stages		Percentage of mortality distributed by causes			
		Alive	*Dead*	*Climate*	*Predators*	*Parasites*	*Proliferation*		*Alive*	*Dead*	*Climate*	*Predators*	*Parasites*	*Proliferation*
July 5, 1929	787	92.81	7.19	2.16	2.63	1.68	.72	4008	92.55	7.45	4.37	1.51	1.51	.06
July 17, 1929	1586	95.91	4.09	.87	.52	2.70		8576	86.87	13.13	9.59	1.97	1.55	.02
Aug. 6, 1929	1216	98.18	1.82	1.30		.52		3963	89.35	10.65	8.85	.70	1.10	
Total	3589	95.70	4.30	1.23	.97	1.95	.15	16,547	88.58	11.42	8.42	1.55	1.43	.02
July 2, 1930	107	95.16	4.84	3.23		1.61		992	55.52	44.48	39.93	1.58	2.97	
July 15, 1930	205	72.59	27.41	25.19		1.48	.74	796	47.86	52.14	49.11	.53	1.25	1.25
Aug. 2, 1930	882	92.45	7.55	6.29		1.26		2678	57.81	42.19	40.57	.36	.36	.90
Aug. 18, 1930	434	93.60	6.40	2.40		3.20	.80	1894	66.64	33.33	32.33		1.00	
Aug. 30, 1930	154	92.68	7.32	7.32				805	79.04	20.96	17.87	.69	.69	1.71
Total	1782	87.94	12.06	9.96		1.72	.38	7165	58.64	41.33	38.52	.70	1.36	.75
June 30, 1931	1323	92.73	7.27	3.91	.13	3.23		3205	87.96	12.04	10.08	.41	1.55	
July 15, 1931	2270	87.03	12.97	6.54	.40	6.03		5141	83.17	16.83	12.62	.29	3.84	.08
July 31, 1931	3849	89.15	10.85	8.36	.03	2.46		6803	88.61	11.39	6.45	2.05	2.89	
Aug. 14, 1931	3813	93.67	6.33	3.82	.45	2.06		7467	79.58	20.42	13.19	4.78	2.45	
Total	11,255	90.76	9.24	6.04	.24	2.96		22,616	84.67	15.33	10.26	2.30	2.76	.01
July 18, 1932	1360	85.09	14.91	7.64	.95	6.21	.11	4651	71.72	28.28	19.52	.80	7.96	
Aug. 3, 1932	936	87.04	12.96	8.34		4.62		3715	72.60	27.40	9.81	5.89	11.20	.50
Aug. 16, 1932	1334	93.42	6.58	3.76		2.82		3493	83.23	16.77	8.48	1.18	7.11	
Sept. 6, 1932	920	92.44	7.56	3.24		4.32		1348	87.36	12.64	7.71	.98	3.95	
Total	4550	88.37	11.63	6.11	.51	4.95	.06	13,207	75.92	24.08	13.55	2.19	8.22	.12

Madison parish, La., selected to include the several soil types of this locality. The term "fallen squares" designates all squares collected from the ground, and the term "hanging squares" designates flared and damaged squares that were found on the plants. During the seasons of 1929, 1930 and 1931 the squares were collected from two points in each of the eight fields. At each point the hanging squares were collected from five parallel rows 100 feet in length, and the fallen squares from the ground between the rows. Thus, squares were collected from 1000 feet of row in each field. In 1932 it was necessary to reduce the area from which the squares were collected to 300 feet of row per point and to only one point in each field.[1]

Table 2.—Mortality of weevil stages in relation to total precipitation, average maximum temperature, and highest maximum temperature for about two weeks preceding collections, Tallulah, La.

	Hanging Squares			Weather Data			Fallen Squares		
Date of Collection	Number infested squares	Dead stages	Per cent mortality	Total precipitation	Average maximum temperature	Highest maximum temperature	Number infested squares	Dead stages	Per cent mortality
7- 5-29	417	9	2.16	1.98	89.2	94	1785	78	4.37
7-17-29	1148	10	.87	1.08	88.1	94	5232	502	9.59
8- 6-29	384	7	1.30	1.12	91.4	95	2441	212	8.85
7- 2-30	62	2	3.23	.15	95.5	100	571	228	39.93
7-15-30	135	34	25.19	.08	95.1	104	560	275	49.11
8- 2-30	159	10	6.29		97.4	104	557	226	40.57
8-18-30	125	3	2.40	1.05	96.4	100	300	97	32.33
8-30-30	41	3	7.32	1.21	85.8	96	291	52	17.87
6-30-31	270	29	3.91	.14	92.1	98	525	168	10.08
7-15-31	994	65	6.54	1.27	92	98	2394	302	12.62
7-31-31	2552	213	8.36	4.98	83.6	92	4187	270	6.45
8-14-31	2177	83	3.82	.79	83.9	95	3619	477	13.19
7-18-32	838	64	7.64	.60	95.6	100	2361	461	19.52
8- 3-32	108	9	8.34	1.84	94.2	97	1374	135	9.81
8-16-32	425	16	3.76	1.65	94	97	1180	100	8.48
9- 6-32	185	6	3.24	.85	92	98	506	39	7.71

The total number of hanging and of fallen squares for each point was determined, and all squares showing boll weevil punctures were separated from those that were shed from other causes. The weevil-punctured squares were dissected to determine the stages of the insects, and whether the larvae, pupae, and adults found were alive, emerged, or dead, and whether death was due to parasites, predators, proliferation, or climatic or unknown causes. From these data the percentage of squares containing egg punctures, larvae, pupae, adults, or emergence cells, and the percentage of stages found dead, were readily computed and the causes of mortality learned.

Table 1 presents the results for each of the collections and examinations made during the four years. The total mortality of weevil stages in hanging squares, table 1 for 1929 was 4.3 per cent; in 1930, 12.06 per cent; in 1931, 9.24 per cent; and in 1932, 11.63 per cent. "Climate"[2] was the principal cause of mortality during the seasons of 1930, 1931 and

[1] The author acknowledges with thanks the assistance rendered by J. C. Clark and A. L. Scales, and by a number of temporary assistants, in the collection of material and the examination of the squares to determine the cause of weevil death, and expresses his gratitude to Paul M. Gilmer, for the correlation of certain phases of the data and for aid in preparation of the manuscript.

[2] By "climate" is meant the sum of all causes of mortality other than parasites, proliferation, and predators. The term is used because such losses have appeared under this classification in the literature.

1932. In 1929, when the mortality of boll weevil stages in squares was much lower than it was for the other three years, parasites caused a little higher mortality than did climatic conditions.

The total mortality of the boll weevil in the fallen squares, table 1, for the season of 1929 was 11.42 per cent; for the 1930 season, 41.33 per cent; for the 1931 season, 15.33 per cent; and for the 1932 season, 24.08 per cent. There is considerable variation in these totals as well as in the several collections made during each season. For each of the four seasons the principal cause of mortality in the fallen squares was climatic conditions. Some mortality was caused by predators, mostly ants, amount-

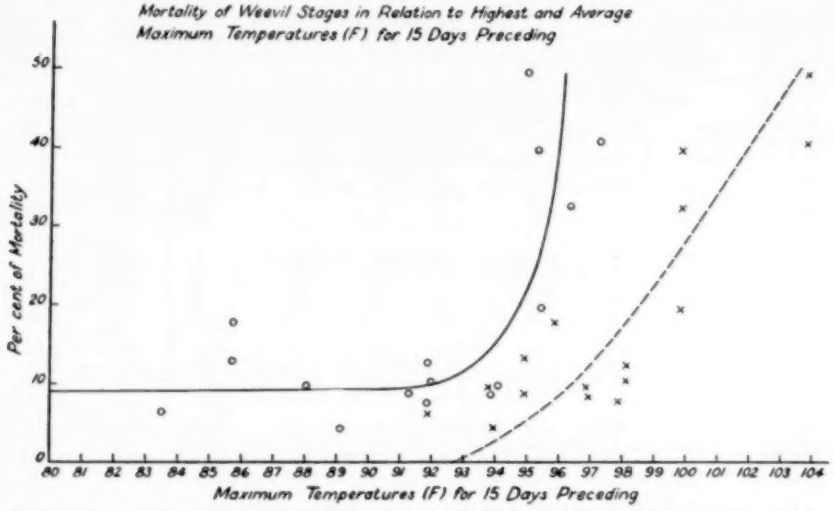
Mortality of Weevil Stages in Relation to Highest and Average Maximum Temperatures (F.) for 15 Days Preceding
Per cent of Mortality
0
10
20
30
40
50
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104
Maximum Temperatures (F) for 15 Days Preceding

Fig. 1. Average maximum temperature —○—. Highest maximum temperature --×--.

ing to a little more than 2 per cent during the 1931 and 1932 seasons. The mortality caused by parasites was due principally to *Microbracon mellitor* Say. Parasitization was rather high during the 1932 season, causing 8.22 per cent mortality or about one-third of the total mortality from all causes combined.

Figures showing climatic conditions for each period are given in table 2. In only one year, 1930, out of the four years in which these studies were made was there a dry season during June and July. During those two months when the main cotton crop was being set in this locality, hardly any rainfall occurred. The number of punctured squares collected in 1930 was much smaller than in any other year, and the percentage of mortality was considerably higher in the fallen squares, but the difference in the hanging squares was negligible, indicating that climatic conditions were largely responsible for the mortality of the boll weevil stages in the fallen squares.

The correlation between the mortality of boll weevil stages and precipitation and temperatures is indicated in table 2 and in figs. 1 and 2.

In table 2, the data from table 1 on mortality due to climate are shown together with such weather data as seem applicable. The listed statistics are, percentage of mortality due to climate, total precipitation for the 15 days preceding the date of collection, and the mean maximum and the highest maximum temperature encountered during the same period of time. The weather data were plotted against the mortality for both hanging and fallen squares, using percentage of mortality as ordinate and the other factors as abscissae.

There seems to be, in the case of the hanging squares, no apparent correlation between any of the climatic factors used and mortality, the

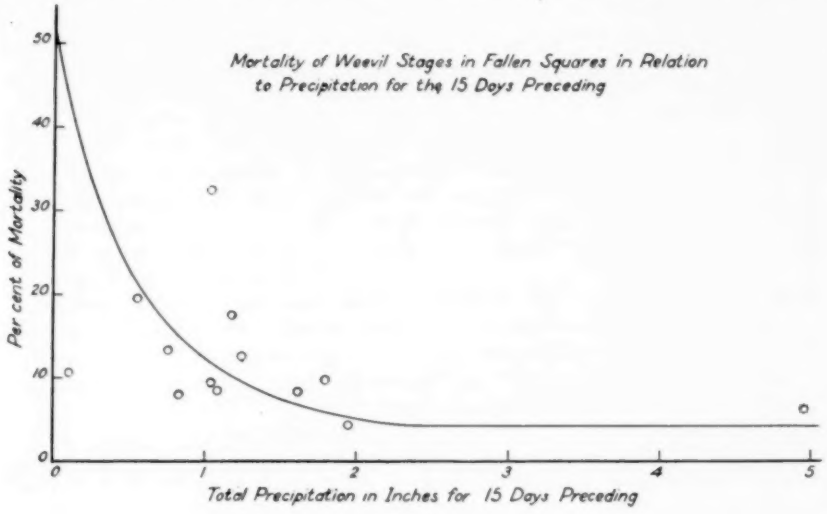

Fig. 2

best fitting "curve" in each case being a straight line parallel with the axis of abscissae, as in fig. 3 dealing with temperature.

From this it would seem to follow that, under the weather conditions at Tallulah, La., covered by the data, there are no climatic effects that are lethal to boll weevil stages in hanging squares. In short, the so-called "climate losses" in the case of hanging squares are not due primarily to any climatic factor but to some other cause.

When examination is made in connection with the fallen squares there is at once apparent a correlation not only with the rainfall over the preceding 15 days (a period approximately covering the total larval and pupal stages of the boll weevil), fig. 2, but also with both the mean and the highest maximum temperatures over the same period, fig. 1.

When the mean maximum temperature was plotted against mortality a free-hand curve of hyperbolic character was drawn to fit the data, this curve having almost a right-angle bend at approximately 93° F. Up to this point the center of distribution of recorded points lies almost parallel with the axis of abscissae, while from that point it tends to become paral-

lel with the axis of ordinates. It would seem that the only interpretation that could be put on this shape of curve would be to suppose that with the average maximum temperature every day approaching 93° F, temperatures developed upon the ground are sufficient to be lethal, and that the effect is not a gradual one but approaches almost to an "all or none" condition so far as boll weevil mortality is concerned.

If, however, the curve for the highest maximum temperatures encountered during the same periods of time be examined, it will be seen quite plainly that the "all or none" assumption is not correct here, but that mortality is the result rather of long discontinuous exposure to such

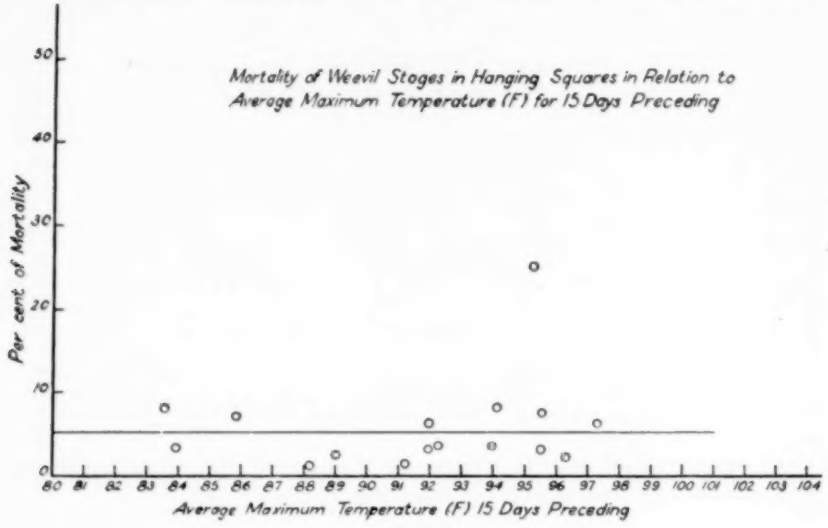
Mortality of Weevil Stages in Hanging Squares in Relation to
Average Maximum Temperature (F) for 15 Days Preceding
Per cent of Mortality
50
40
30
20
10
0
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104
Average Maximum Temperature (F) 15 Days Preceding

Fig. 3

temperatures, as there is a very distinct correlation between height of highest maximum and percentage of boll weevil mortality, the low point again being somewhere near 93° F and rapidly increasing to the highest point recorded (50 per cent mortality) at maximum temperatures approaching 105° F.

Since, however, temperatures as high as 105° F produced little if any excess in mortality of boll weevil stages in squares hanging freely in the air, it is quite evident that the actual lethal temperatures must be considerably higher, and are developed only in contact with some surface such as the ground.

Examination of the data with reference to the effect of rainfall shows, in the case of the fallen squares, a curve similar in shape to that found in the case of the mean maximum temperature, except that it is the mirror image of the temperature curve. With rainfall much less than an inch and a half over the 15-day period, mortality was likely to be high, while precipitation in excess of that amount tended to reduce mortality. The points are rather scattered; and the inevitable conclusion that must be

reached is that the curve itself is the result, in all probability, not of a direct correlation between precipitation and mortality, but between precipitation and some factor related to both precipitation and mortality. The most obvious factor so related would be temperature, which should vary inversely with the amount of precipitation, owing not only to the immediate cooling effects of rain, but also to the extension of cooling effect due to the large quantity of heat required to effect the slow evaporation of moisture from the soil.

An examination of the correlation between highest maximum temperature and rainfall over the periods involved shows that this relation does exist markedly, a curve based on these corresponding beautifully both in slope and direction with the mortality-rainfall curve. The effect of precipitation upon mean maximum temperature is much less marked, although a distinct correlation can be shown to exist.

It is evident that continued high temperatures are not necessary to effect kill, unless those temperatures are of relatively low maxima, that is, of the order 90–94° F, but that a single day much above 95° F is sufficient to produce heavy mortality of the boll weevil in stages in contact with the earth and fairly exposed to the action of the sun.

The results shown in this paper confirm the conclusion reached by previous writers regarding the effects of temperature on the immature stages of the boll weevil.

Conclusions.—The chief factors effecting boll weevil mortality in the immature stages are climate, predators, parasites, and proliferation. Of these, climate is ordinarily the most important in the case of fallen squares, although of relatively small importance in hanging squares. In both cases, the order of efficiency of the other factors seems to be parasites, predators, and proliferation. Temperature is the most important element in the climatic factor, and this has its greatest effect on squares lying on ground exposed to the sun. The effective fatal maximum temperatures lie from 93° F upward, varying in efficiency almost directly with increase above that figure.

FIELD-PLAT AND CAGE TESTS FOR BOLL WEEVIL CONTROL[1]

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The field-plat and cage tests for boll weevil control covered by the present paper were made at Tallulah, La., in 1933 and 1934.

EXPERIMENTAL METHODS USED IN FIELD-PLAT TESTS

Arrangement of plats.—The cotton fields in which the tests were to to be made were selected early in June of each year. Each field selected had been planted throughout with the same variety of cotton on the same date and was apparently uniform with respect to soil fertility, plant growth, stand, and weevil infestation. The aim was to select fields

[1] Field-plat tests by M. T. Young and cage tests by G. L. Smith, under direction of R. C. Gain

that could be divided into a given number of plats the potential production of which would be equal were it not for the different treatments given. All plats of a given test received the same cultivation throughout the season, and, where fertilizer was used, the same quantity per acre was applied. In each test the plats were arranged in series and were parallel to one another, the number of rows used in each plat ranging from 18 to 26. The length of each plat depended on the length of the rows in the field, and was 300 feet or more in all tests, except on Islington H. In each test one plat was always left untreated, and when two or more insecticides were compared one was always the standard calcium arsenate.

Poison applications.—Poison applications on the plats selected for treatment were begun as soon as a boll weevil square infestation of 10 per cent was reached and, in so far as weather conditions permitted, were continued at four-day intervals as long as necessary for weevil control. The treated plats were dusted with hand guns in the early morning, between daybreak and 7:30 a.m., when the cotton plants were wet with dew, and the atmosphere was calm. In a test with two or more treated plats, all were dusted on the same dates at approximately the same time of day. Whenever a heavy rain occurred within 24 hours after an application was made, this application was regarded as of no value, and another was made as soon as possible.

The two mixtures of calcium arsenate and hydrated lime and the mixture of calcium arsenate and copper arsenite were factory products. The mixture consisting of 1 pound of thiodiphenylamine and 9 pounds of dusting sulfur, and the three derris-root dust mixtures were prepared in a small mixing machine at the laboratory. The derris-root dust mixtures used for the first and second applications on Evergreen B and for those on Islington I and J were prepared by mixing the proper quantity of derris-root dust containing 4 per cent rotenone with flour to make the desired dilutions, but kaolin clay was substituted for flour in all the remaining applications.

Square-infestation records.—The square-infestation records were begun when the cotton plants had an average of four or five squares large enough to be punctured by boll weevils, and were made at weekly intervals until the average number of squares per plant was less than four or five. These records were taken from points near the center of each end and in the center of each plat. The plants were taken consecutively on several rows at each point, and every square on each plant that was large enough to be punctured by a boll weevil was examined until 200 squares had been counted at each of the three points in a plat, or 600 squares per plat. The number of squares examined and the number of punctured squares found at each of the three points were recorded, and the average percentage of square infestation was then calculated for each plat.

Yield records.—At the time plats were laid off, the areas for dusting were extended 25 feet or more beyond the ends of those portions of the plats on which records were to be made. Just before picking time areas consisting of these 25 feet or more at the ends and of five or more rows on each side of the plats were discarded. Thus the rows which might have

been affected by treatments on adjoining plats were eliminated. This left in most plats a uniformly treated area of approximately one-fourth acre on which two or three pickings were made. The yield per acre was computed from the quantity of cotton picked from this area in each plat.

Boll Weevil Cage Tests

Experimental methods.—Frame cages, 4 by 4 by 4 feet, covered on the tops and sides with 16-mesh screen wire were placed over individual cotton plants. The cages rested on skeleton platforms with 6-inch legs set in pails of water to prevent ants from entering the cages, the stems

Table 1.—Boll weevil mortality in cage tests, Tallulah, La., 1933 and 1934.

Treatment	1933		1934	
	No. tests	Average mortality, per cent	No. tests	Average mortality, per cent
Hydrated lime			6	34.3
Calcium arsenate 1 part, hydrated lime 2 parts	8	37.5	6	66
Calcium arsenate 1 part, hydrated lime 1 part	8	49.8	6	69.8
Calcium arsenate	10	77.5	6	86.4
Untreated	10	9	6	33.3
Thiodiphenylamine 1 pound, dusting sulfur 9 pounds			6	64.3
Calcium arsenate			12	82.7
Untreated			12	36.7
Calcium arsenate 80%, copper arsenite 20%	7	69.9	6	78.8
Calcium arsenate	7	85.5	6	84.9
Untreated	7	12.1	6	36.1
Derris-root dust 2% rotenone			6	72.9
Derris-root dust 1% rotenone			6	52.6
Derris-root dust .5% rotenone			6	42.5
Calcium arsenate			6	81.8
Untreated			6	32.8

of the plants being covered by a sticky banding material, and stretched across the platforms were white cloths which served as cage bottoms and caught any weevils that fell from the cotton plants.

Boll weevils were collected by the hoop and bag method from unpoisoned cotton fields, and when the cages were ready 25 active weevils were released in each cage on one afternoon, and on the following morning about sunrise the cotton plant in the cage was dusted with the insecticide under study. Small hand dust guns were used in applying the insecticide.

During the four days following the dust application the cages were examined at frequent intervals for dead weevils, and all found were recorded and removed. At the last observation on the fourth day the number of live boll weevils remaining in the cage was also determined. Computations of weevil mortality were made from the actual number of live and of dead weevils observed.

Presentation of results.—Table 1 gives, for the cage tests, the insecticides used, the number of tests conducted, and the average mortality for each treatment. For each test three cages were used. The insecticides used in the cage tests were identical with those used in the field-plat tests with one exception—the derris-root dust mixtures used in all cage tests were prepared by mixing derris-root dust containing 4 per cent of rotenone with kaolin clay.

Table 2.—Poison applications and cotton yields on field plats in boll weevil control tests, Tallulah, La., 1933 and 1934.

Year	Cut and Period of Treatment	Treatment of Plat	Total Applications	Effective Applications	Average Quantity Dust Used, Pounds per Acre per Application	Yield of Seed Cotton, Pounds per Acre	Increase in Yield of Treated Plats over Untreated Plats	
							Pounds per Acre	Per cent
1933	Evergreen B	Calcium arsenate	11	6	7.31	1307	496	61.2
	Jul. 18–Aug. 16	1 part calcium arsenate, 1 part hydrated lime	11	6	6.91	1197	386	47.6
		Untreated				811		
		1 part calcium arsenate, 2 parts hydrated lime	11	6	7.39	1031	220	27.1
1934	Dalkeith B							
	June 28–Aug. 7	Calcium arsenate	10	10	5.97	1548	416	36.7
		1 part calcium arsenate, 1 part hydrated lime	10	10	6.75	1711	579	51.1
		1 part calcium arsenate, 2 parts hydrated lime	10	10	7.22	1548	416	36.7
		Untreated				1132		
1934	Islington H	Untreated				1407		
	June 30–Aug. 11	Calcium arsenate	12	9	6.01	2008	601	42.7
		1 part calcium arsenate, 1 part hydrated lime	12	9	6.68	1979	572	40.7
		1 part calcium arsenate, 2 parts hydrated lime	12	9	6.87	1813	406	28.9
1934	Maxwellton C	Calcium arsenate	5	5	5.61	957	70	7.9
	July 7–28	1 part calcium arsenate, 1 part hydrated lime	5	5	5.97	944	57	6.4
		1 part calcium arsenate, 2 parts hydrated lime	5	5	6.72	926	39	4.4
		Untreated				887		
1934	Evergreen D	Untreated				634		
	Jun. 29–Jul. 24	Hydrated lime	7	7	6.94	670	36	5.7
1934	Evergreen E							
	Jun. 29–Jul. 24	Hydrated lime	7	7	6.37	888		
		Untreated				983	95*	10.7*
1934	Maxwellton E	Hydrated lime	5	5	6.03	1130	30	2.7
	July 7–28	Untreated				1100		
1934	Islington F	Calcium arsenate	6	5	5	1757	210	13.6
	July 20–Aug. 8	1 lb. thiodiphenylamine, 9 lbs. dusting sulfur	6	5	5.08	1607	60	3.9
		Untreated				1547		
1933	Evergreen C	Calcium arsenate 80%, copper arsenite 20%	10	5	5.99	1992	1056	112.8
	Jul. 13–Aug. 16	Untreated				936		
		Calcium arsenate	10	5	8.14	1468	532	56.8
1933	Montrose A	Calcium arsenate	11	*8	6.91	841	187	28.6
	Jul. 16–Aug. 25	Untreated				654		
		Calcium arsenate, 80%, copper arsenite 20%	11	8	5.99	827	173	26.5
1934	Dalkeith A	Untreated				1582		
	Jun. 28–Aug. 7	Calcium arsenate 80%, copper arsenite 20%	10	10	5.15	1718	136	8.6
		Calcium arsenate	10	10	5.59	1618	36	2.3
1934	Dalkeith C	Calcium arsenate 80%, copper arsenite 20%	10	10	5.50	1752	414	30.9
	Jun. 28–Aug. 7	Calcium arsenate	10	10	5.26	1652	314	23.5
		Untreated				1338		
1934	Islington K	Calcium arsenate 80%, copper arsenite 20%	11	8	5.40	1593	376	30.9
	Jun. 30–Aug. 6	Untreated				1217		
		Calcium arsenate	11	8	5.56	1544	327	26.9
1934	Evergreen B	Calcium arsenate	10	8	5.73	1567	482	44.4
	Jul. 8–Aug. 11	Derris-root dust, 1% rotenone	10	8	5.41	929		
		Untreated				1085	156**	16.8**
1934	Islington I	Derris-root dust, .5% rotenone	10	7	6.20	1220	2	.2
	Jul. 8–Aug. 11	Untreated				1218		
		Calcium arsenate	10	7	5.83	1474	256	21
1934	Islington J	Calcium arsenate	10	7	5.84	1653	730	79.1
	Jul. 8–Aug. 11	Untreated				923	38**	4.3**
		Derris-root dust, 2% rotenone	10	7	6.69	885		

* Increase untreated over hydrated-lime-treated plat.
** Increase untreated over derris-root dust-treated plat.

Table 3.—Square infestation on field plats in boll weevil control tests, Tallulah, La., 1933 and 1934.

Year	Cut	Treatment of Plat	Percentage of Squares Found Punctured at Weekly Intervals						
			June 19–25	June 26–July 2	July 3–9	July 10–16	July 17–23	July 24–30	July 31–Aug. 6
1933	Evergreen B	Calcium arsenate		13.3	15.7	6.3	9.2	14.7	21.7
		1 part calcium arsenate, 1 part hydrated lime		9.7	9	6	8	17.2	25.8
		Untreated		7.2	10.5	15.7	23.7	31	63.8
		1 part calcium arsenate, 2 parts hydrated lime		5	9.5	4.5	12	12.2	18.3
1934	Average of 3 plats, Dalkeith B, Islington H and Maxwellton C	Calcium arsenate	18.6	13.6	20.5	17.3	11.7	12.1	
		1 part calcium arsenate, 1 part hydrated lime	20.2	15.8	29.2	32	24	37.9	
		1 part calcium arsenate, 2 parts hydrated lime	18.2	13.2	27.9	34.1	35.9	54.4	
		Untreated	22.1	19.6	30.7	48.1	56.2	75.6	
1934	Average of 3 plats, Evergreen D and E and Maxwellton E	Hydrated lime	17.5	13.6	29.6	49	53.5		
		Untreated	15.1	13.6	23.1	45.7	45.1		
1934	Islington F	Calcium arsenate	3	2.5	5.5	24.7	39.8		24.7
		1 lb. thiodiphenylamine, 9 lbs. dusting sulfur	2	.8	5	19	35.2		64.3
		Untreated	2.5	1.5	4.7	19.8	38		63.8
1933	Average of 2 plats, Evergreen C and Montrose A	Calcium arsenate		13.8	9.3	18.4	13.5	32.7	33.2
		Calcium arsenate 80%, copper arsenite 20%		19.4	14.4	11.4	14	29.9	24.2
		Untreated		15.2	10.1	19.6	22.1	46.6	57
1934	Average of 3 plats, Dalkeith A and C and Islington K	Calcium arsenate	25.8	23.5	23.2	18.6	14	7.9	
		Calcium arsenate 80%, copper arsenite 20%	19.2	20.6	19.5	16.6	18.1	9.7	
		Untreated	23.4	22.2	33.9	42.8	58.5	52.6	
1934	Evergreen B	Calcium arsenate	11.2	28.8	61.8	52	28.3	28.3	
		Derris-root dust, 1% rotenone	14.7	23.3	57.3	56.2	74.3	82	
		Untreated	17	29.8	54.8	61.2	74.2	80.5	
1934	Islington I	Derris-root dust, .5% rotenone	14.2	23.7	35.7	59.7	67.2		
		Untreated	18.3	20	25.2	59.3	71.3		
		Calcium arsenate	12.7	15.7	32.3	35.5	11.2		
1934	Islington J	Calcium arsenate	21.7	26.5	70.8	58.8	34		
		Untreated	23.8	21.5	66.3	79	85.8		
		Derris-root dust, 2% rotenone	24.5	37	61.3	73.3	82.3		

Table 2 gives the insecticides used in the dust applications on the treated plats, the total number of applications, and the number of effective applications on each plat. In this table the effective applications are those which were not washed off by rain within the first 24 hours. Table 2 also shows the production of seed cotton per acre for each plat and the increase in yield for the treated over the untreated plats or, in a few cases, the increase in yield for the untreated over the treated plats, in pounds and percentages.

The average percentages of square infestation for these tests, at weekly intervals, are given in table 3. Where two or more similar tests were made in the same year the averages for these tests are used instead of those for each individual test.

Comparison of results.—In Evergreen B in 1933 the square-infestation records indicated very good weevil control in the plats treated with the two calcium arsenate and hydrated lime mixtures, but the yields were not so great as in the plat treated with calcium arsenate alone. The average percentage of square infestation in the three tests conducted in 1934 indicated better boll weevil control in the plats treated with calcium arsenate than in those treated with the calcium arsenate and hydrated lime mixtures, but the average yields were greatest in the plats treated with one part of calcium arsenate and one part of hydrated lime, and next greatest in the plat treated with calcium arsenate alone. The average increased yields of seed cotton per acre in the four tests was 396 pounds for the plat treated with calcium arsenate, 399 for the plat treated with one part of calcium arsenate and one part of hydrated lime, and 271 for the plat treated with one part of calcium arsenate and two parts of hydrated lime. It will be noted, however, that in three of the four tests the greatest increased yields were made in the plats treated with calcium arsenate alone.

The square infestation and the yield records in three tests indicate that hydrated lime has no value for boll weevil control. These field-plat tests with lime and lime mixtures, generally speaking, verify the results in cage tests.

The mixture of thiodiphenylamine and sulfur had very little, if any, effect on the percentage of square infestation, but the yield of the plat treated with the above named mixture was 60 pounds of seed cotton per acre greater than in the untreated plat. However, this increased yield was too small to be significant and was probably due to a variation in the stand of cotton in the plats. In the cage tests it will be noted that a greater mortality was recorded for the thiodiphenylamine and sulfur mixture than in the untreated cages, but less than that recorded in the cages treated with calcium arsenate.

The square-infestation records indicated that the calcium arsenate and copper arsenite mixture gave equally as good or better weevil control than calcium arsenate alone. In four of the five tests the calcium arsenate and copper arsenite plats, yielded better than the calcium arsenate plats. The average yield for the five tests in the plats treated with the calcium arsenate and copper arsenite mixture was 152 pounds of seed cotton per acre greater than in the plats treated with calcium arsenate

alone. In the cage tests calcium arsenate alone produced a somewhat higher mortality than the calcium arsenate and copper arsenite mixture, but the difference was not great.

Derris-root dust mixtures containing .5, 1, and 2 per cent of rotenone, based on the square infestation and yield records, gave very little, if any, weevil control. The failure of the plats treated with derris-root dust in two tests to yield as well as the untreated plats indicates that the derris-root dust mixtures when used at the rate of 4 to 6 pounds per acre had no value as a means of boll weevil control. The results with derris in cage tests do not agree with the results in field plat tests. The higher boll weevil kill in the cages was probable due to the fact that the boll weevils were stupefied shortly after the applications of derris-root mixtures were made and would fall to the cage bottoms where they lay exposed to the sun and were killed before they recovered from the effects of the derris.

OBSERVATIONS ON *MICROBRACON MELLITOR* (SAY) IN RELATION TO THE BOLL WEEVIL

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These biological observations on the most abundant parasite of the boll weevil were made at Tallulah, La., in the season of 1934. They add something to the account given by Fenton & Dunnam.[1]

After cages of various kinds in which to raise the parasites were made, the cage shown in fig. 1 was constructed. It proved to be satisfactory in every way. The body of this cage, resting on sand in a saucer, and covered with a Petri dish, is a cardboard cylinder, 2 inches high and $3\frac{1}{2}$ inches in diameter, cut from an ice cream box. On the left side is a hole closed with a cork covered with absorbent cotton, on which food (equal parts of honey and distilled water) for the parasites is placed. On the right side is a second stoppered hole for the introduction of parasites and cotton squares and the removal of squares, and for other purposes. The parasites were introduced from glass tubes of the size of the opening. When these tubes were darkened, the insects, going toward the light, went into the cage.

A cage of this form permits observation of its inmates with the aid of a binocular magnifier. For study under higher magnifications, with a binocular microscope, the insects were confined in glass tubes.

Oviposition.—In the field the eggs are laid either in squares on the plant or in squares lying on the ground. They are not laid in very small squares but usually in squares about one-half to three-fourths of an inch in length. It seems to make no difference to the female whether the squares are fresh and green or old and brown, provided they are not too

[1] **Fenton, F. A.,** and E. W. Dunnam. 1929. Biology of the cotton boll weevil at Florence, S. C. U. S. D. A. Tech. Bul. 112. 76 pp., illus. (See pp. 66–8.)

hard. Before squares were placed in the cages, their bracts were removed.

At first the cages were provided with squares that showed an egg puncture of the boll weevil, and after oviposition in a square had been observed, that square was split open and examined for the egg of the parasite and for previous parasitization. For convenience of study a parasitized weevil larva was often transferred from its dirty cell to a clean

Fig. 1.—Cage for rearing parasites.

cell, made by splitting a sound square in halves, removing the contents, and pinning the halves together again. In fact, if a healthy weevil larva is placed in such an artificial cell, the parasite will oviposit on the larva just as usual, preferring to insert its ovipositor through the slit that it finds ready made. After this was learned, this method was used exclusively in rearing the parasites, especially since it insured freedom from previous parasitization.

Weevil pupae, instead of larvae, were placed in these artificial cells some thirty times. In only one instance was an egg laid on a pupa.

When naked weevil larvae, whether living or parasitized, were placed in the cages, the parasites did not lay their eggs on them; in fact, paid no attention to them.

The female does not oviposit for at least 24 hours after eclosion. She usually begins to lay eggs on the second day after emerging, but occasionally not until the third day.

Before laying an egg the female walks over the square and tests its suitability for oviposition. Tests showed that she is not guided in the least by the wart that indicates the egg puncture of the boll weevil, and she never used this puncture for oviposition. She finds where to insert the ovipositor by means of the tactile sense. A square that contains a boll weevil larva that is somewhat advanced in growth is no longer hard and solid, but is yielding to the touch because it is hollow inside. So the female presses the tip of the ovipositor against the square, here and there. A hard resisting spot makes the ovipositor bend. In a soft yielding spot she proceeds to lay an egg.

The two outer valves of the ovipositor form a strong black tube, entirely covered with short dense hairs, presumably tactile in function. These valves form a sheath for a pair of slender brown stylets, which do the drilling, and which also form a tube through which the poison and the eggs pass. These stylets constitute the sting proper, or *terebra*.

While the square is being tested, the ovipositor is held at right angles to the body. Having located a suitable spot, the female releases the terebra from between the two outer valves, inserts it into the square, and moves it in and out until its entire length pierces the wall of the square. When this operation begins, the pair of outer valves is curved backward, like a bow, and the terebra in its movements is supported and guided between the tips of the outer valves. As the terebra bores in, the outer valves curve forward against it to form a channel, along which it moves.

The parasite first stings the boll weevil larva and paralyzes it, then lays an egg on or near the larva. The time required for oviposition during August and September was determined by a series of 212 observations. The maximum duration was 90 minutes in one case, the minimum three minutes in seven cases, and the average 15.4 minutes. The majority of individuals completed oviposition in from five to 15 minutes. These were instances in which eggs were laid. It often happened that a female would go through the motions of oviposition without actually laying an egg.

The females oviposited most actively in August, with the mean daily temperature ranging from 81 to 87° F and the maximum from 90 to 100°. The number of eggs laid daily by one female was not large—commonly one or two and rarely three or four. One female laid 48 eggs in 37 days. Usually only one egg was found with each weevil larva; rarely two, and in one instance four.

After an egg has been laid, the weevil larva in the square is found to be alive but motionless. The pulsations of its dorsal vessel are abnormally slow and intermittent, and are variable in rate. Thus 24, 26, 29 and 30 per minute were noted. In a normal larva the rate of pulsation increases with the activity of the larva, but ranges between 42 and 60, inclusive, per minute.

Egg.—The egg of the parasite is visible to the naked eye and is easily seen with a hand lens. Commonly it is placed anywhere on the body of the boll weevil larva, to which it adheres slightly, but sometimes it is found on the wall of the weevil cell, or protruding through the wall. The egg is pearly white, smooth, and elongate clavate in form. Its length ranges from .98 to 1.15 mm., and its greatest width is usually .19 mm.

In August, eggs hatched as a rule in a little less than 24 hours. Two hatched in about 21 hours, and two in about 23 hours, at mean temperatures of 81–84° F. In one instance the egg period was determined exactly, for oviposition ended at 9:20 a.m. on August 20, and on the next day, at 10:10 a.m., the larva was just completing its emergence from the eggshell. Thus the period was 24 hours 50 minutes; the mean temperature was 87° F.

At hatching the larva simply bites away the anterior end of the eggshell with its sharply pointed mandibles, leaving a ragged hole.

Larval growth.—The parasitic larva at hatching is translucent white, with a head and thirteen segments, and from 1.1 to 1.4 mm. in length. It crawls about actively on its host, but soon inserts its mandibles through the skin and begins to feed.

The growth of the larva is rapid. Three days after hatching, as a rule, the larva is 2.6 to 3 mm. in length, has completed its feeding, is full grown, and spins its cocoon. The feeding period varies somewhat. Not infrequently it is four days in length, especially in September and October in cool weather. After this period only the skin and the head of the host remain.

The adult parasites vary enormously in size. This difference in size depends upon the amount of nutriment of the larva; in other words, upon the size of the weevil larva that served as host.

Spinning.—The full-grown larva, inside the square, spins its cocoon on the wall of the weevil cell. Attached by its tail, the larva begins the cocoon by spinning a loose framework of long threads in all directions, moving the head and fore part of the body in circles, and forward and backward and rubbing the head up and down against the wall of the square to fasten each thread in place. After an outer irregular network of long threads has been laid, the larva locates the meshes by poking its head through them, and proceeds to spin short threads across the holes. After ten hours of constant spinning the larva is barely visible through the cocoon. The completed cocoon is white, dense, and tough, like parchment. In the cocoon the excreta of the larva are discharged for the first time, as a dark-brown fluid.

At eclosion the adult escapes by eating away the anterior end of the cocoon and then gnawing a small round hole through the square above the calyx.

Larval and pupal development.—The normal period from hatching to eclosion, in August and September, was 12 days. Of these 12 days the first three were spent as a feeding larva, then a cocoon was spun in which it remained as a larva for six days and as a pupa for three days. Thirty-seven per cent of the males, or 52 individuals, and 38 per cent of the females, or 23 individuals, emerged in 12 days after hatching, at a mean

temperature of 73° F. The daily maximum temperatures were, however, in the nineties or high in the eighties.

Six per cent of the males and 6 per cent of the females emerged in 11 days after hatching. Fifteen per cent of the males and 8 per cent of the females developed in 14 days.

This developmental period ranged usually from seven to 16 days, according to the temperature chiefly, though one male emerged on September 20, after 17 days from the egg, and one on October 17, after 21 days; the normal periods having been prolonged by cool weather.

Mating and parthenogenesis.—The process of mating was often observed. It is performed quickly as a rule, and is over in 15 to 30 seconds. Mating is not essential to oviposition, however. Unmated females laid eggs readily, after the usual preoviposition period. From eggs laid by females that had not mated, 47 adults were produced—all males. Twenty-one of these, or 44 per cent, emerged in 12 days after hatching, at a mean temperature of 75° F. The remainder issued in 10, 11, 13, 14, or 15 days.

Females which were mated with these parthenogenetic males produced normal eggs and larvae.

Longevity.—During the warmest part of the season, in August, when the adults were most active, their average length of life was about two weeks, and females lived a few days longer than males. In the cooler part of the season, in September and October, when the adults were less active, they lived longer. Thus one male lived 27 days (until Sept. 21), two males 38 days (until Oct. 25), one 39 days (until Oct. 26), and one 41 days (until Oct. 26). Of the females, the maximum records were: 31 days (until Sept. 24), 38 days (until Oct. 25), 39 days (until Oct. 26), 42 days (until Oct. 27), and 70 days (until Nov. 19).

In all these instances the parasites were fed with equal parts of honey and distilled water. They did not live long without food. Unfed males averaged three days of life (range two to seven days) and unfed females five days (range one to six days).

Autumn history.—The first killing frosts at Tallulah, La., in 1934, came on November 12, 13, and 15. The first of these killed 90 per cent of the boll weevil larvae in hanging squares, and the second frost finished the remainder. Oviposition by the parasite out of doors came to an end at this time.

Adults had been issuing daily until October 11. Thereafter only six emerged; on October 12, 14, 16, and November 11 and 23, respectively. All these were females. Ninety-four cocoons remained, from which adults have not emerged up to December 19, when this paper was written. These cocoons are being kept at outdoor temperatures. Some of them were opened and found to contain living larvae, as did also two cocoons found in fallen squares on the ground on November 10. This indicates that the species is able to overwinter in the cocoon.

Whether it winters also as an adult is not certain. In a room slightly warmer than the outdoors, adults were kept alive after killing frosts came. In cold weather these parasites were stiff and motionless, but they became active when warmed by sunshine or artificially. Then they fed

and laid eggs in weevil-infested squares that had been collected before cold weather came. These adults indoors gradually died off, though two females and one male were still alive December 19. After frost the eggs required at first four or five days to hatch, and eggs laid on December 3, 5, and 7 hatched in 12, 11, and 10 days, respectively.

In the study of this parasite, assistance was rendered by P. A. Glick, assistant entomologist, Bureau of Entomology and Plant Quarantine.

PROGRESS REPORT ON THE KEY WEST (FLORIDA) FRUIT FLY ERADICATION PROJECT

WILMON NEWELL, *Plant Commissioner, State Plant Board of Florida*

Early history.—On November 6, 1930, two larvae, identified as being *Anastrepha* sp., were found infesting hog plums, *Spondias mombin*, in Key West. Discovery was made by agents of the Plant Quarantine and Control Administration, United States Department of Agriculture. Following this discovery, intensive inspections were made by inspectors of the administration and of the State Plant Board of Florida of all fruit growing on the island, and on adjacent Keys. Two additional larvae were collected from hog plum on November 12, and five pupae were obtained on November 12 and 14 by sifting soil. The above represented the findings on two properties.

Continued and intensive inspections were made during 1931, when, in September, infested hog plums were found on one property. From this infestation adult flies were reared which were identified as being *Anastrepha fraterculus* Wied. Comparisons with type material subsequently disclosed the fact that these flies were not *A. fraterculus*, but *A. suspensa* (Loew) and *A. acidusa* Walk. No further infestations were found in 1931. In September 1932, infestations of hog plums were found in 81 properties, in guavas, *Psidium guajava*, on six, in Barbados cherries, *Malpighia* sp., on three properties, making a total of 90.

Biological investigations.—In September 1932, research activities, with the view of ascertaining some knowledge of the life history and habits of the pest, were instituted. This work, begun by the Plant Board, was soon after taken over by the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture. Through the efforts of L. C. McAlister, Jr., who in November was assigned to biological investigational work by the Bureau of Entomology and Plant Quarantine, certain facts of great value in an eradication project were brought to light. These included:

1. The determination that several species of *Anastrepha* occur on the island, (a) *A. acidusa*, (b) *A. suspensa* and (c) an undetermined species. (Hog plums seem to be the preferred hosts of *A. acidusa;* guavas seem to be preferred by *A. suspensa.*)

2. Establishment of the fact that in cages under laboratory conditions some 34 different fruits are attacked by *A. acidusa*, and 11 by *A. suspensa*.

3. That a mixture of tartar emetic (antimony and potassium tartrate) 4 pounds, syrup 5 gallons, and water 100 gallons, is highly toxic to these fruit flies in a comparatively short time.

Eradication campaign.—While regulations intended to prevent spread had been promulgated and in effect for some time, no effort with the view of eradication was made until the summer of 1933. On August 1, after consultation with and upon the advice of representatives of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, an eradication campaign was instituted by the State Plant Board. This program involved, in addition to continued quarantine, inspectional and investigational activities, the destruction of all fruits which had been found in field inspection to be subject to attack (guavas, hog plums and Barbados cherries), and the repeated application to host-producing trees of a spray consisting of tartar emetic, syrup and water. In addition to trees bearing field hosts, all trees producing fruits shown to be subject to attack in cage tests were included in the spray program.

The number of field host fruit trees growing at Key West is listed below:

Barbados cherry	162 trees
Hog plum	272 trees
Guava	2507 bushes

Local conditions at Key West.—Key West is the southernmost of the major keys extending southward off the east coast of Florida. Its nearest neighbor is Havana, Cuba, located 90 miles across the Gulf stream to the southward. Its nearest American city of importance is Miami, 125 miles northeast.

Housing conditions in Key West make exceedingly difficult the enforcement of any eradication measures. The small yards are covered with outhouses, chicken coops, and the ever-present and essential cistern. On wash days the remaining space is taken up with drying clothes. Application of the molasses spray material, with the imperative need of keeping it out of cisterns, off of the clothes, and away from open windows, is a task requiring both discretion and skill.

It is evident from the foregoing that in enforcing eradication measures in Key West it is necessary to deal with the conditions in a manner somewhat different than would be the case in other parts of the state or country.

Progress of eradication.—Since August of 1933 an effort has been made to maintain a host-free condition on the island. As a rule, there is but one hog plum crop, which starts to mature in the late summer. The main guava crop ripens at about the same time. In two successive years these two crops have been removed and the fruit destroyed. Barbados cherries, which have about three crops annually, together with off-season

guavas, are removed before they reach maturity. A constant check is made of each property for the purpose of locating and removing ripening host fruits.

An application of tartar emetic spray is applied at two-week intervals. The program calls for spraying of all fruit trees—known field hosts and others. We are frank to admit that every property is not sprayed on schedule. The presence of drying clothes or the temporary objections of the property owner at times calls for the omission of some properties. This is not regarded as a serious condition. Drift from spray applied to trees in adjoining properties tends to minimize the risk from these unsprayed properties.

Infestation record.—The following tabulation is a record of infested properties found by years, the host affected, as well as the number of adult flies collected in traps, from November 6, 1930 to December 31, 1934.

Year	Hog Plum	Guava	Barbados Cherry	Fig	Soil[1]	Total	Traps, Adults
1930	2					2	
1931	1					1	
1932	81	6	3			90	
1933	1	4	1		3	9	1
1934				1?		1?	33

Intensive eradication measures were first applied in August 1933. Of the nine infested properties recorded for 1933, seven were found during the spring, one (guava) during the latter part of August before all the guavas were removed, and one (hog plum) in the early part of September. This latter infestation was found in a fruit overlooked by the clean-up crews.

While included as a matter of record, there is some question as to the fig infestation during 1934. On February 5, 1934, two pupae were recovered from a pupation tray on which figs had been placed on January 30. One of these pupae was sent to Washington for determination by experts attached to the Bureau of Entomology and Plant Quarantine. Latest reports indicate that neither C. T. Greene nor F. H. Benjamin is absolutely certain that the specimen belongs to the genus *Anastrepha*.

Examination of fruit in laboratory.—Since inauguration of eradication measures in August 1933, many thousands of fruits of all kinds have been placed on pupation trays in the laboratory. Each lot is recorded as to date of collection and property from which taken. In addition to the use of pupation trays, many lots of fruits have been run through the Benjamin machine, where a solution of formaldehyde causes any larvae to leave the fruit and fall into a trap cup. Hundreds of pupae and thousands of larvae have been recovered from trays and the Benjamin machine and sent to the board's entomologist at Gainesville during the past eighteen months, all with negative results.

Adult flies and traps.—Our belief that great strides have been made in the eradication of fruit flies at Key West may be questioned after a

[1] In the spring of 1933 soil sifted under trees—variety not recorded—gave up pupae on three different properties.

study of the above tabulation showing an increase in the number of adult flies collected.

It should be noted that no adults are recorded prior to 1933. Up to June 1933, wire fruit fly traps, similar to those used during the Mediterranean fruit fly campaign, were used in Key West. Although baited with many different materials, their use was negative. On July 1, 1933, about 25 glass McPhail traps were received. Baited with a fermenting mixture of citrus juice and brown sugar, these traps immediately demonstrated their superiority over the old ones. In September 1933, some hundred additional traps were received at Key West, and subsequent shipments, the last in November 1934, have increased the total number of traps to five hundred. The increase in the number of adult flies captured may be attributed chiefly to the increase in the number of traps used. Clensel, a commercial attractant used with considerable success in trapping activities elsewhere, is now being extensively experimented with.

While no comparisons can be made, the fact remains that adult flies were present in large numbers prior to institution of intensive eradication measures. The following is quoted from the "Report on Investigations of the West Indian Fruit Fly at Key West, Florida, November 21, 1932 to November 11, 1933," by L. C. McAlister, Jr., Bureau of Entomology and Plant Quarantine.

> The population of flies at Key West was probably the greatest in November 1932, when hog plums were generally heavily infested with *Anastrepha acidusa*. Barbados cherries were infested lightly with the same species, and guavas were infested by both the species *A. acidusa* and the species *A. suspensa*. Adult flies were readily observed and captured in the field as late as December 20, 1932.

The increase in the number of flies captured may be attributed to an increase (from 25 in July 1933 to 500 in November 1934) in the number of traps used. Traps are not used as a control measure, but merely as an indication of the progress of eradication.

Quarantines.—Since March 1932, inspectors have been stationed at the railway station, ferry slip and docks at Key West and No Name Key for the purpose of enforcing the board's regulations prohibiting the movement of host material from the quarantined area.

Inspection in other localities.—Following discovery of the fruit fly in 1930, intensive inspections were made of all Keys and of the mainland in south Dade county. In addition, many lots of guavas, hog plums and other susceptible fruits were collected and sent to Key West for placement on pupation trays. A special crew of inspectors was assigned to fruit fly inspection in Dade county in the summer of 1933. Intensive inspections in that area up to the fall of 1934 failed to disclose any infestation.

Cooperation.—Since the finding of infestation in 1930 by federal inspectors there has been the closest possible cooperation between state and federal officials. Assistance in the form of supplies, equipment, personnel, funds and counsel has been rendered by those in charge of the

Bureau of Entomology and Plant Quarantine. Although the field work in connection with this campaign is being directed by officials of the State Plant Board of Florida, the activity is distinctly cooperative. State funds have been supplemented by federal funds derived through the Bureau of Entomology and Plant Quarantine. Two large federal trucks equipped with Fitzhenry Guptill power spray units, as well as a smaller Bean power spray outfit, have been supplied by the bureau, and the bureau now has one of its entomologists stationed at Key West studying insect conditions with special reference to West Indian fruit fly.

State and local administrators of the FERA have since the beginning of intensive eradication measures manifested the keenest interest in the project and have rendered valuable aid in contacting and consulting with local residents, as well as with allotments of money and labor.

Conclusion.—After several years of observation and biological investigations, and eighteen months of intensive eradication activities, it is felt that progress has been made towards its goal—eradication of fruit flies from Key West. Realizing fully, and much more so than can anyone not familiar with local conditions, the many difficulties to be overcome before the task is completed, we feel that, barring the unforeseen, eradication is possible without prohibitive cost and at a comparatively early date.

CONSIDERATION OF THE FIRE ANT *SOLENOPSIS XYLONI* AS AN IMPORTANT SOUTHERN PEST

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Although the common name "fire ant" is applied to a number of species and their variants of the genus *Solenopsis*, the common Gulf coast form *Solenopsis xyloni* is the most important throughout the south. To the average individual they are generally known either as "red ants" or "stinging ants." As the ants are polymorphic and their major workers distinctly red, whereas the minor workers are much darker, people often get the impression that there are two distinct species troubling them. In size, these forms range from 1.6 to 5.8 mm. The formicologist or entomologist recognizes the worker of this species by its two-segmented antennal club, toothed clypeus, lack of epinotal spines, two-segmented petiole, shining body, etc.

The species *S. xyloni* occurs within an area bounded on the north approximately by the 35th degree of latitude and extending from the Atlantic to the eastern boundary of Arizona, with the exception of most of Florida, where it is replaced by the tropical fire ant *S. geminata* and its subspecies. It is especially abundant and troublesome in the Gulf coast region.

Careful checks by the writer of the abundance of colonies of these ants on blocks in various Mississippi towns have shown a range from five to

fifty per cent of the total ant colonies, with a general average of 20.5 per cent. If the density per block were based on the number of individuals rather than colonies, the density would be much greater for the fire ant because of its unusually populous colonies. The density in the rural areas is apparently equally as great. While no careful counts have been carried on to determine the population of various fire ant colonies, excavations of approximately 80 colonies by the writer and an assistant have shown that most colonies must be estimated in the thousands. In one nest, actual count of the dead ants in a single chamber totaled 2360 workers, and this conservatively was probably not more than one-tenth of the entire nest.

Generally the nests are in freely exposed soil areas, but the ants also nest in the soil under debris, such as boards, stones, cow chips, etc., or often around or beneath clumps of grass, strawberry plants, shrubbery and other plants. They often next in rotten wood, and on many occasions they were apparently nexting in masonry work. Many times nests are found in greenhouses or beneath residences, especially around fire hearths where, due to the artificial heat, their colonial activities go on uninterrupted the year round. The common form of next architecture in the soil is that of multiple craters often scattered over areas of amazing extent. One large nest was approximately 10 by 24 feet; the average, however, is probably not over two to four feet square. An experienced person can recognize the craters or piles of earth made by fire ants by the shape of the soil particles and the generally loose or fluffy manner in which the earth is piled. If one steps on a nest or jars it by design, there is an outpouring of angry ants, stinging viciously.

A tabulation of the data secured during the Argentine ant survey conducted by the United States Bureau of Entomology in sixteen states showed that of the 75 species found troublesome, exclusive of the Argentine ant, the fire ant *S. xyloni* was responsible for 15.7 per cent of all complaints.

In Mississippi, the fire ant has only one close competitor as an economic species—the Argentine ant, which is more important as a house pest but does not perhaps have as wide range of injurious habits as the fire ant. In Mississippi, with the exception of the tropical fire ant and Florida harvesting ant *Pogonomyrmex badius* Latr. there are no other ants that have the ability to inflict any really painful stings. On people with tough skins, although painful or uncomfortable, the stings have no appreciable after effects. On babies or small children, they can often leave sores. Workers in the garden, lawn, orchard or field may be subject to the attack of these ants at any time. On numerous occasions they have been reported as destroying poultry and quail at the time of hatching.

The fire ant is also a most general and annoying house pest. Although omnivorous in its feeding habits, the ants show a distinct preference for meats, grease, butter, nuts and other greasy foods. So far as the writer knows, the Argentine ant never gnaws holes in clothing, table linen or bed linen. That the fire ant does this is an established fact. The writer has seen many silk, woolen, linen and cotton articles with small holes gnawed in them by the ants. Apparently soiled articles are more attrac-

tive to them, but clean clothes are also attacked. In greenhouses and vegetable gardens the ants often cause poor stands through their habit of stealing seeds from the beds, this being particularly true of the smaller seeds. They assiduously attend a large number of species of mealybugs, plant lice and scale insects; in some instances not only are cartons built over certain mealybugs, but the ants resist attempts to remove the mealybugs from their host. It is common knowledge to nurserymen and others that the ants often girdle young nursery stock, such as citrus and pecan. The writer has also seen the ants gnawing into the buds of okra and althaea, the stems of dahlias, and the base of the fruits of eggplants. Irish potato tubers are often scarified or gnawed into as well as strawberries. Entomologists rearing insects frequently lose many specimens because of the predatory fire ant. In many instances, fire ants destroy serious insect pests, such as immature stages of the boll weevil, the sorghum midge and others, yet these beneficial habits will hardly offset their many and serious economic injuries.

Although the fire ant has probably as many natural enemies as most ants, these do not seem to exert any appreciable control. On several occasions the writer has seen chickens feeding on the ants at the time of their nuptial flights when their activity and abundance on the soil was especially noticeable. Several phorid flies belonging to the genus *Plastophora* parasitize them, but no one has yet worked out the biology of these parasites, so it is not known exactly how they operate on the ants or the amount of reduction they cause.

The writer's observations and experiments over a period of years apparently indicate that fire ants cannot be successfully poisoned with a sweet bait, such as the Argentine ant poison. Limited experiments with poisoned baits of greases, meats and nuts, in which arsenicals or tartar emetic have been incorporated, have shown slightly beneficial results, but not enough to be entirely satisfactory. At this time, experiments in the fumigation of nests (where accessible in the soil) have shown very promising results in which effectiveness, low cost and other desirable features are combined. Occasionally, nests are located in houses inaccessible for treatment, and here the only recourse is a poisoned bait. The importance of the fire ant in the south would justify a great deal more research on its habits and control than is now being given to it.

NOTES ON PINK BOLLWORM SEPTICEMIA

G. F. White and L. W. Noble, *U. S. D. A., Bureau of Entomology and Plant Quarantine*

In the summer of 1932 a disease was observed among pink bollworms used in rearing parasites at the laboratory of the Division of Cotton Insect Investigations, Presidio, Tex. The disease was observed only under laboratory conditions and has not been noted in the field. Inasmuch as the disease interfered with the breeding of parasites by destroying the host insects and caused additional labor in the operation of the

laboratory, a preliminary study of the malady was considered desirable.

Symptoms.—Only full-grown pink bollworm larvae that had completed feeding were used in the parasite laboratory, so that no observations on the disease were made on other instars. The infected mature larvae became sluggish in the early stages of the disease. Soon after death their bodies became brown, the shade deepening within a few hours from light brown to a dark brown or almost black.

Microscopic examination of smears made from sick and recently dead worms showed the presence of numerous bacteria. No fungi, protozoa or polyhedral bodies were found. Cultures from these worms revealed the presence of only a few bacterial species. Prominent among these were two species of *Bacillus* and one of *Streptococcus*.

Experimental inoculations.—The three bacterial species were obtained in pure cultures and healthy pink bollworms were inoculated with them. Healthy worms were inoculated also with material direct from diseased ones.

The puncture method was followed in making the inoculations. The body wall of the worms was pierced by a fine dissecting needle that had been sterilized by flaming, cooled, and contaminated by thrusting it into the tissues of a sick or recently dead worm, or by touching an agar culture. The inoculated worms were held at a practically constant temperature of 80° F and a relative humidity of 65 per cent.

Check larvae punctured with a sterile needle, or with one dipped into the body fluid of another healthy worm, suffered no infection therefrom. These worms pupated and the adults emerged in good condition. Of 20 worms inoculated direct from diseased worms, three died and became discolored within 24 hours, after 36 hours seven additional worms died and the remainder of the group appeared to be sick, and within 48 hours all were dead.

The inoculation of worms with one of the species of *Bacillus* isolated and with the *Streptococcus* respectively indicated that neither of these was pathogenic. Of 50 worms inoculated with a pure culture of the other *Bacillus*, the mortality was 100 per cent within 24 hours.

Name of the disease and of the causal organism.—The symptoms of, and the bacteriological findings in, the disease show that it belongs to the septicemia group of insect diseases. Following the plan adopted earlier for members of this group of infections (White, *1*, *2*), the name "pink bollworm septicemia" has been given to the disease. Following a similar plan for choosing a name for the bacterium that is present in the septicemia and that is the immediate cause of death of the worms, the name *Bacillus pectinophorae* is given to it. The species is a small, actively motile, non-spore-bearing rod which forms gray colonies on agar. Members of this septicemia group of bacteria are easily destroyed by heat, drying, sunlight and chemical disinfection. The other *Bacillus* isolated also forms gray colonies on agar, is small, motile and non-spore-bearing, but is not pathogenic.

Metalnikov & Metalnikov (*3*, *4*), studying diseases of the pink bollworm, report a mortality of 90 to 99 per cent from natural infection in the field in 1932 and 1933. It is seen from the description of the micro-

organisms which they encountered that they were not working with pink bollworm septicemia.

Further observations.—In parasite rearing it was noted that the paralyzed worms were somewhat resistant to pink bollworm septicemia. It was thought that this apparent resistance might be due to the fact that the circulation of the pink bollworm was stopped or practically stopped and the bacteria were not carried to the different parts of the body as rapidly as in the case of normal worms. From all external appearances, the so-called paralyzed worms were dead. Some of these worms were inoculated for comparison with inoculated normal worms. Worms killed by hot water were also inoculated for comparison with these two groups. All of the 10 normal worms inoculated in this test died and turned dark brown within 48 hours. Of the group killed by hot water and inoculated, four discolored within the first 48 hours and the other six had discolored after four days. Four of the paralyzed worms discolored during the first 48 hours after inoculation, one began to discolor on the third day, and the other five remained in a preserved state for nine days. Two of this group retained their normal color for 20 days.

When collecting pink bollworms for parasite breeding or other laboratory work, losses due to pink bollworm septicemia may be greatly reduced by practicing preventive measures. The worms should not be crowded in containers, as when thus crowded they produce excessive moisture, which makes conditions unfavorable; possibly also the worms under these conditions may bite each other, allowing easy entrance of the bacillus causing septicemia. Parasite-breeding cages and other receptacles should be sterilized by heating.

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The Pennsylvania Department of Forests and Waters placed an order effective January 15, establishing two white-pine blister-rust control areas within which no currant or gooseberry plants may be planted or maintained. One of the areas is comprised of 44 counties and part of another, and the second area consists of zones surrounding a nursery in Erie county.

Transit inspection activities of the Bureau of Entomology and Plant Quarantine are being expanded through the assignment of additional inspectors at various railway terminals to inspect nursery stock shipments in compliance with federal domestic plant quarantines. The work is conducted on a year-round basis at Boston, New York, Philadelphia, Pittsburgh, Washington, Jacksonville, Cincinnati, Chicago, St. Paul and Omaha, and on a part-year basis at Detroit, Cleveland, St. Louis, Kansas City, Portland, Ore., Spokane and Seattle. State inspectors are assisting at a number of these points. Early in December twelve additional inspectors were assigned to assist in checking holiday shipments, with special attention to the movement of Christmas trees and Christmas greens from the gypsy moth-infested areas of the New England states. Inspectors were stationed at Albany, N. Y., and Springfield, Mass., for several weeks during the winter.

PAPER-READING SESSION, TWENTIETH ANNUAL MEETING
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THE CITRUS RED MITE *PARATETRANYCHUS CITRI* McG. IN CALIFORNIA, AND ITS CONTROL[1]

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The citrus red mite *Paratetranychus citri* McG., more commonly known in California as the citrus red spider, constitutes one of the major pests of citrus in the southern portion of the state. This species was long considered to be *Penthalodes mytilaspidis*, described by Riley in 1885 from orange in Florida. Banks placed it in the genus *Tetranychus* in 1900, and in 1916 McGregor determined that the citrus red mite had never been described. He therefore described it as *Tetranychus citri* and later placed it in the genus *Paratetranychus*. Various workers considered *P. citri* a synonym of *P. pilosus* Can. & Franz, the European red mite; however, the work of McGregor & Newcomer (*4*) apparently yielded ample evidence to establish these two mites as distinct species.

The citrus red mite, probably introduced into California from Florida about 1890, has been an important pest on citrus in this state since 1895. The principal studies concerning this mite in California have been by Woodworth (*8*) in 1900 and by Quayle (*6*) in 1912, the latter being the most extensive.

Hosts.—The citrus red mite is practically limited for hosts to species of citrus. In California the lemon appears to be the most favorable host species. The Washington navel orange, the Valencia orange, and the grapefruit are apparently favored as hosts in the order given.

Distribution and climatic limitations.—The citrus red mite is apparently native to North America and occurs in all of the citrus-producing states in the United States, with the possible exception of Arizona. It is more important in California than elsewhere, though it is a pest of moderate importance in the lower Rio Grande valley of Texas and in the satsuma orange districts of Alabama and neighboring gulf states, and of minor importance in Florida. In the citrus areas outside of California it is known by the common name of purple mite.

In California this mite thrives best under relatively cool, semihumid conditions and is distinctly limited in its distribution by climatic conditions. It is of economic importance only in the coastal and certain of the subcoastal areas where relative humidity is generally higher than in the interior valleys; where spring, fall and winter temperatures are somewhat higher; and where summer temperatures are lower.

[1] Paper No. 327, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

Under normal conditions the peak infestations usually occur in the spring, from April through June; however, they are frequently of importance in the fall, from October to December. During exceptionally warm winters, heavy mite populations may exist from the fall throughout the entire winter and spring; and occasionally during unusually cool summers, they may occur in certain areas throughout the summer. In the San Diego section they commonly occur throughout the whole year.

Populations of this species fluctuate in a very erratic manner within plantings in a relatively small area and also within the confines of an individual small planting. The nature of this behavior is improperly understood at present, though an extensive study of the biology and ecology of this mite is in progress.

Nature of injury.—The mites feed on the leaves, fruit and green bark of new growth, abrading the tissue in extracting plant sap. Affected areas lose their normal color, becoming pale grayish or silvery, and normal color is not restored after the mites disappear. In heavy infestations practically all of the foliage and fruit on the tree exhibit characteristic injury. There is commonly severe defoliation, followed by a dying back of the twigs. Proper functioning of the affected tissue is evidently impaired and furthermore when warm, dry winds occur, many of the affected leaves on the windward side of the tree are dehydrated or burn and drop. Under certain conditions, injury to the fruit may cause it to be marketed in a lower grade, while under other conditions it is possible that the ultimate size of the fruit may be adversely affected.

Biology.—The red, nearly spherical, somewhat flattened, stalked eggs, with guy fibrils radiating from the tip of the stalk to the substrate, are mainly deposited on the leaves, fruit, and twigs. From 20 to 50 eggs per female are produced; they hatch in from eight to thirty days or longer, depending upon prevailing temperatures. There are three molts, and under most favorable conditions maturity may be reached in as short a period as eight days after hatching. The sexes occur in about equal proportions; however, parthenogenetic reproduction may occur, in which instances only males are produced. There may be many generations produced during a year, and populations build up to high densities very rapidly under favorable conditions.

Control.—Until the advent in about 1925 of the highly refined mineral oils for citrus sprays, sulfur in some form had been largely used for the control of the citrus red mite. Sublimed sulfur and ground sulfur both were used as early as 1902 (*7*) as dusts and sprays or washes, and apparently afforded satisfactory control. Sulfide of potash was also used at that time. Flour paste was quite generally incorporated in sulfur sprays as an adhesive agent. Distillate sprays were effective in killing the mites and eggs; however, repeated applications were necessary, since adequate coverage could not be obtained under practical conditions with the equipment available. Excessive tree injury and an objectionable spotting of the fruit in certain instances caused spraying with distillates to be discontinued. As a result of studies by Quayle (*6*), from 1910 to 1912, a sulfur-hydrated lime dust, three parts sulfur to one part of lime, or lime sulfur used at a concentration of 2 per cent, was recommended and

generally afforded satisfactory results. However, within the past six or eight years the use of sulfur and its compounds for citrus red mite control has been very limited. This fact is due principally to the following causes: (1) superiority of oils for this purpose and the more general use of oils as a combination treatment for control of scale insects and this mite; (2) unsatisfactory results in the control of citrus red mite by sulfur as compared with the results secured in former years; and (3) hazard of fruit injury caused either by dry, hot winds in certain sections or by a sudden increase in daily temperature after sulfur applications. Certain observers have suggested that possibly the citrus red mite is becoming resistant to sulfur. There are no actual data to substantiate this view. However, there seems to be some basis for the belief held by several observers that citrus trees are more susceptible to injury from sulfur than they were twenty years ago. Another factor to be considered is that the populations of citrus red mites apear to be generally heavier than formerly. This may be due to the scarcity in recent years of the several species of insects predacious on the mite. The available evidence indicates that the rather general use of oil on citrus trees of late years has adversely affected these natural enemies. This may or may not be the explanation, and it is a matter upon which quantitative information is difficult to obtain. Oil sprays have been used yearly on a large portion of the plantings where climatic conditions are favorable to citrus red mite. The mite population is almost annihilated by the regularly used oil sprays and usually remains at a very low ebb for from eight to ten months after such treatments. Therefore, because of lack of food, the natural enemies do not persist in sufficient numbers, if at all, to begin to build up when the mite population increases. Consequently, there may not be a sufficient supply of them generally distributed in any large area to exert as great an inhibiting effect on the mite population as in former years. Such factors as these may also tend to explain the decreased effectiveness of sulfur during recent years for citrus red mite control. It is possible that in the past the sulfur reduced the mite population sufficiently for the natural enemies that were present to destroy most of those that remained.

In most sections, under ordinary conditions one application of oil spray in the fall of the year usually affords satisfactory protection from damage by the citrus red mite for about one year. However, after the use of an oil spray, if climatic conditions are extremely favorable to mite development throughout the winter and spring, or throughout the summer, there usually develops a need for mite control with a material that contains little or no mineral oil. Furthermore, in certain instances the yearly application of oil on citrus is undesirable; therefore there is an urgent demand for a material other than oil for controlling this mite in groves where fumigation with hydrocyanic acid gas is practiced for control of scale insects. Fumigation usually has no appreciable effect in reducing the mite population; in fact, mite populations commonly increase after fumigation, since many of their natural enemies are killed.

During the epidemic condition of citrus red mite in 1932–33, caused

by unseasonable weather conditions, further study regarding control was undertaken.

When this study was begun, the proprietary selenium compound, *Selocide* and a lime sulfur—iron sulfate combination were both being used to a limited extent for citrus red mite control. *Selocide* was developed by C. B. Gnadinger (*2*) in 1931, while he was studying the control of the common red spider *Tetranychus telerius* (Linn.) in greenhouses. *Selocide* concentrate is a 30 per cent solution of potassium ammonium seleno-sulfide, $(KNH_4S)_5Se$.

Lamiman (*3*), in his studies on the control of the Pacific red spider *Tetranychus pacificus* McG. on grapes in California, determined that at a concentration of 1–800, *Selocide* concentrate was very effective under outdoor conditions; a concentration of 1–200 had been previously used under greenhouse conditions. Gnadinger (*2*) showed that lime sulfur at 1–300, or light-medium mineral oil[2] at 1–300, increased the effectiveness of the *Selocide* (1–600) spray mixture in the control of the citrus red mite. He concluded that oil as an adjuvant increased the effectiveness more than did the lime sulfur. However, under commercial field usage, the *Selocide* with either oil or lime sulfur as an adjuvant occasionally gave unsatisfactory results. Therefore, a large portion of the early work of the present study pertained to *Selocide*.

Many laboratory tests and several hundred control experiments in the field were conducted in the various citrus red mite areas. These were principally designed to determine the most effective (1) concentration of *Selocide;* (2) adjuvant, such as lime sulfur, wettable sulfur, or oil; and (3) spreading and wetting agent to use. The data show that *Selocide* at 1–800 is as effective as any of the higher concentrations that are practical to use. An adjuvant is essential for maximum efficiency, the most satisfactory ones apparently being lime sulfur at 1–300, wettable sulfur at 1 to 2 pounds per 100 gallons of spray mixture, or light-medium mineral oil at 1–300. The *Selocide*—lime sulfur or wettable sulfur combination affords a high degree of kill of those mites contacted, although it apparently kills only those eggs in which the embryo is almost fully developed. However, a residuum is deposited on the tree that kills the young mites shortly after they are hatched even during relatively low temperatures and under conditions when the residuum from a 2 per cent lime sulfur spray or regular sulfur dust is ineffective. The residuum from the *Selocide*—lime sulfur or wettable sulfur combination apparently is a specific compound that is formed when these materials are combined. Definite information regarding the chemical nature of this residuum is not available. The use of this combination may not effect satisfactory control when rains follow the application within a period of several weeks and wash the residuum off the foliage and fruit, thereby permitting the mites that subsequently hatch to survive.

The *Selocide*—oil combination effects a high initial kill of those mites and eggs contacted; however, there is apparently no residual effect from

[2] Light-medium mineral oil as used in this paper refers to an oil of the following specifications: 90 per cent unsulfonatable residue; distillation range—10 per cent at 587° F, 50 per cent at 632° F, 90 per cent at 702° F.

the use of this combination and, therefore, unless the application is very thorough, the results may not be satisfactory. A comparison of many parallel experiments with the *Selocide*—lime sulfur combination versus the *Selocide*—oil combination shows that the latter has generally afforded a higher degree of control, although in certain individual experiments it frequently happened that the former combination was superior.

When it became evident that each combination possessed certain specific merits, tests were conducted in which both lime sulfur and oil at 1–300, and both wettable sulfur at 1 pound per 100 gallons and oil at 1–300 were combined with *Selocide*. Tree injury occurred under certain conditions with the *Selocide*—lime sulfur—oil combination. However, the *Selocide*—wettable sulfur—oil combination appeared to be relatively noninjurious to the tree and afforded very effective control of the mite.

Four new selenium formulas submitted by C. B. Gnadinger have been tested. In these, either the amount of selenium, or the material in which it is dissolved, or both, were varied. Two of these formulas are promising enough to warrant further study.

Several spreading and wetting agents, such as calcium caseinate, blood albumin, soaps, sulfonated plant oils, and sulfated alcohols have been tested. According to present information, calcium caseinate, at the rate of $\frac{1}{3}$ pound per 100 gallons of spray mixture, is the most satisfactory material to use with any of the *Selocide* combinations.

The combination of lime sulfur at 2 gallons and iron sulfate at 2 pounds per 100 gallons of water, as used by Miller & Yothers (*5*) in Florida, was used experimentally and commercially in 1933. In most instances the incorporation of iron sulfate in the spray mixture materially increased the effectiveness in mite control; however, it apparently also increased the hazard of fruit injury during high temperature. The substitution of aluminum sulfate for ion sulfate in the mixture gave practically the same results as the latter material. It was, however, somewhat more desirable, since it did not interfere with the normal coloring of the fruit beneath the spots of spray residue. Zinc sulfate was used also, since it is of value in correcting the mottle-leaf disease of citrus trees. However, it was not as effective as the other sulfates used with lime sulfur for mite control. None of these lime sulfur—sulfate combinations was satisfactory enough in mite control to become established.

Two of the proprietary aliphatic thiocyanates, *Loro* and *Lethane*, have been tested at various concentrations and in various combinations. Further experimental work is necessary in order to determine definitely the merits of these materials in mite control. Furthermore, present cost somewhat limits the use of these materials for mite control solely; however, in connection with their possible use in the control of citrus aphids and unarmored scale insects, they will exert a controlling effect on citrus red mite.

Laboratory tests of several phenol compounds, paradichlorobenzene, naphthalene, and certain naphthalene derivatives have been conducted. The phenol compounds as used do not appear to offer much promise in control. Paradichlorobenzene (200 gm) dissolved in light-medium min-

eral oil (2000 cc.), and used at the rate of 1–200, has been tested in both the laboratory and field. Likewise, naphthalene (400 gm) was dissolved in carbon bisulfide (1000 cc.); to this mixture was added light-medium mineral oil (400 cc.). The solution was used at the rate of 1–400. Both of these combinations have given promising results, although further work is necessary in order to obtain conclusive data regarding the merits of these compounds. Beta naphthol, chlor beta naphthol, alpha naphthol, alpha naphthylamine, and tetralin (tetra-hydro naphthalene) are also being investigated.

The proprietary chlorinated naphthalene product *Halowax* (*1*) has been tested fairly extensively. When used at a concentration of .5 per cent, in combination with .5 per cent light-medium mineral oil in several types of emulsions, promising results in citrus red mite control were obtained. However, in most instances, from slight to serious foliage injury occurred.

Various concentrations and combinations of rotenone, finely powdered derris and cubé root, pyrethrum extract, finely powdered pyrethrum flowers, free nicotine, and nicotine sulfate, have been tested under field conditions. None of these products as used, even at concentrations that are commercially prohibitive, exhibited a sufficient degree of toxicity to the citrus red mite or its eggs to be considered promising in control.

Conclusion.—The citrus red mite problem in California is increasing in importance, particularly with regard to control. Mineral oil sprays are ideal from the viewpoint of mite control; however, there are certain conditions under which oil sprays are undesirable with respect to the citrus tree. At present, the most promising material other than oil in mite control is *Selocide*, although in certain areas and under certain conditions in all areas, the *Selocide* combinations used have not always given satisfactory results. Further work with selenium, sulfur, naphthalene, thiocyanates, oils, and other materials is in progress.

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NOTES ON THE ORANGE WORMS *ARGYROTAENIA (TORTRIX) CITRANA* FERN. AND *PLATYNOTA STULTANA* WLSM.[1]

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This paper presents data on the relative abundance in southern California of the orange worms *Argyrotaenia (Tortrix) citrana* Fernald, and *Platynota stultana* Walsingham,[2] and on the effect of the injury to young oranges caused by their newly hatched larvae.

The orange tortrix, *Argyrotaenia (Tortrix) citrana*, was originally taken on oranges in the Glendora district in Los Angeles county, California, in 1886. While it has many other host plants, it is of economic importance principally to citrus and is by far the most abundant and destructive of the so-called "orange worms" in southern California.

Platynota stultana was described by Walsingham in 1884, from specimens taken at Sonora, Mexico, with evidently no record of the original host. This species also has many hosts and is frequently reported as injurious to greenhouse plants, such as carnations and roses. It has also been reported as injurious to youngberries and has been found in shipments of green peppers from Mexico. The writer's earliest experience with an infestation of *Platynota stultana* on citrus was in 1925, when a considerable infestation was found in a top-worked orange grove where the larvae were working as leaf-rollers on the young shoots. There was no fruit on the trees. In January 1928 the writer visited the grapefruit district of Yuma, Arizona, in response to a reported infestation of lepidopterous larvae, and found infestations of *Platynota stultana* in two groves. The larvae were not only working as leaf-rollers on the grapefruit trees and alfalfa cover crop, but were also damaging the fruit by eating holes into the rind and sometimes through to the flesh. In a collection of 27 larvae, all produced adults of *Platynota stultana*.[3]

In California, *Platynota stultana* has been more damaging to citrus in fiction than in fact. At the inception of the orange worm project in 1924, *Platynota stultana*[4] Wlsm. was considered as one of the important orange worms, but the specimens pointed out to the writer as this species proved to be the then little known *Holcocera iceryaeella* Riley, which was recorded in literature as a beneficial insect but has since been found[5] to be an orange pest second in importance to the orange tortrix.

The young of any of these orange worms crawl under the "button" or

[1] Paper No. 328, University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

[2] For the synonomy of *Platynota stultana* the reader is referred to **Busck, A. E.** 1933. Ent. Soc. Wash. Proc. **35**: 191–2.

[3] Determined at that time by A. E. Busck, of the U. S. Department of Agriculture, as *Platynota chiquitana* B. & B., which has since been found to be synonymous with *Platynota stultana* Wlsm.

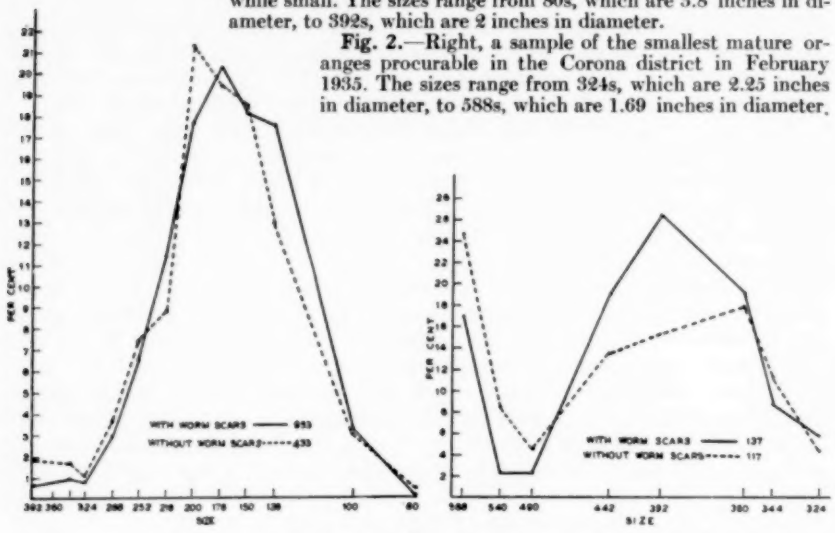
[4] Known then as *Platynota tinctana* Walker, but since found to be *Platynota stultana* Wlsm.

[5] **Basinger, A. J.** 1924. A supposedly beneficial insect discovered to be a citrus pest. Jour. Econ. Ent. **17**(6): 637. Dec.

sepals of oranges and grapefruit if the fruit happens to be small when the larvae hatch. This offers a protected place, where in feeding they nibble on the fruit. The injury causes a scar in the mature fruit which may be slight, or form in extreme cases a complete, more or less narrow, ring around the stem, resembling thrips injury. In 1933 and 1934 young orange worms appeared in abundance in various localities at the time the new fruit was setting and marked a high percentage of the fruit. These infestations were reported[6] as *Platynota stultana*, and it was further stated that the injuries stunted the growth of the fruit, causing the formation of the so-called "pee-wee" oranges. Our data show that the infestations

Fig. 1.—Left, packing-house sizes at maturity of fruits tagged while small. The sizes range from 80s, which are 3.8 inches in diameter, to 392s, which are 2 inches in diameter.

Fig. 2.—Right, a sample of the smallest mature oranges procurable in the Corona district in February 1935. The sizes range from 324s, which are 2.25 inches in diameter, to 588s, which are 1.69 inches in diameter.


PER CENT
WITH WORM SCARS —— 953
WITHOUT WORM SCARS------433
392 360 324 288 252 216 200 176 150 138 100 80
SIZE
PER CENT
WITH WORM SCARS —— 137
WITHOUT WORM SCARS------ 117
588 540 490 442 392 360 344 324
SIZE

were composed almost wholly of *Argyrotaenia* (*Tortrix*) *citrana*, with a very small percentage of *Platynota stultana* and *Holcocera iceryaecella*, and that the injuries are not the cause of pee-wee oranges.

Argyrotaenia (*Tortrix*) *citrana* and *Platynota stultana* are both tortricids with similar habits and general appearance. The early larval stages of the two species are easily distinguished but the later stages are not. The larva of the orange tortrix has a head capsule of a straw color or differing little from the general body color in all stages; whereas the larva of *Platynota stultana* has a dark to black head capsule[7] until the time of the third molt, when this is replaced by a straw-colored head capsule for the remainder of the larval stages. Thus at the time when the small larvae were present under the sepals, which was during the first and

[6] **McGregor, E. A.** 1934. *Platynota stultana* Wlsm. (Lepidoptera) damaging green oranges in southern California. Jour. Econ. Ent. **27**(5):974. Oct.

[7] During the first instar the head capsule of *P. tinctana* is only slightly darker than that of *A. citrana* but during the second and third instars *P. tinctana* has a quite black head capsule.

second instars, the *Platynota* had more or less black head capsules in contrast to the straw-colored head capsules of the orange tortrix. In June 1934 we examined hundreds of small oranges under the binocular microscope to note the condition of the worms present in order to determine the effect of control experiments. One miscellaneous lot of 302 very young larvae taken from under the sepals of oranges from the Corona district were kept and reared in the laboratory. The lot produced 195 adult moths, of which 192 were orange tortrix and only three were *Platynota stultana*. The remainder, 107, died before reaching maturity. Other localities, La Verne, Claremont, Azusa, had a similar very small percentage of *Platynota stultana*. Since that time (June 1934) there have been two complete generations of *Argyrotaenia* (*Tortrix*) *citrana* and the third is in progress now (June 1935), but the percentage of *Platynota* to the orange tortrix is still very small.

In June 1934, to determine the effect of worm injury to the fruit, tags were placed on over 2000 small green oranges while worms were present under the sepals. For data on the effect of the injury on the grade of the fruit, the fruits were measured and the degree of injury noted at the time the crop was picked, in January 1935. The fruits were picked and run through the packing house in separate lots. We thus procured data on the effect of the injury on the growth or size of the fruit and on the grade or marketability.

In one lot of 953 scarred fruits, the peak in sizes was represented by 176s, of which there were 20 per cent; 76.8 per cent were 200s or larger, and only .63 per cent were 392s or smaller. In a lot of 433 unscarred fruits, the peak in sizes was represented by 200s, of which there were 21 per cent; 75.5 per cent were 200s or larger, and 1.85 per cent were 392s or smaller. The data are shown in fig. 1. Had there been a stunting effect, the damaged fruits should have had a preponderance of smaller sizes and a high percentage of 392s or smaller—the so-called pee-wees.

From the above data it was evident that pee-wee oranges were the result of some other cause. If that is a fact, then there should be among them a certain percentage of undamaged fruits as well as those with various degrees of injury. This is borne out by data from a sample of 254 of the smallest, mature oranges that could be found in a large Washington navel planting in the midst of a heavy infestation of orange tortrix and where the percentage of scarring of the young fruits was high in June 1934. This sample was taken in February 1935, and since there was an unusual scarcity of pee-wee oranges this season in the Washington navel districts generally, the average size of the smallest oranges was greater than last year. These fruits ranged in size from 324s to 588s. It required one man several hours and the examination of many trees to procure the lot. These oranges had among them 46 per cent without a trace of worm scar and 54 per cent with various degrees of injury from a trace to a more or less complete ring, just as one finds among oranges of normal size. The data are shown in fig. 2.

Any blemish on the surface of an orange tends to lower it in grade and thus reduce its marketability. It had been generally supposed that these worm scars would reduce the fruit at least one grade if not more. In the

Corona district, where the packing houses made four grades of oranges—fancy, choice, standard and cull—the scarring had no appreciable effect on the grade. In the La Verne district, one house was packing five grades—extra fancy, fancy, choice, standard and cull. To this house we took 529 oranges which bore the more conspicuous type of worm scars but otherwise represented extra fancy or fancy fruits as nearly as we could judge from the unwashed fruit on the trees in the field. This lot was run through the house in a normal procedure, the graders having no knowledge of the experiment. It was graded as follows:

Extra fancy	204 = 38.56	per cent
Fancy	313 = 59.17	per cent
Choice	9 = 1.70	per cent
Standard	3 = .57	per cent
Cull	0 = 0	per cent

To conclude, then, it has been pointed out that both *Argyrotaenia (Tortrix) citrana* Fernald and *Platynota stultana* Wlsm. have been known for about 50 years; that the orange tortrix is the most important orange worm; that *Platynota stultana* may do damage to citrus but during the seasons 1934 and 1935 it was present as a calyx worm in only a very small percentage of cases. It was further shown that the injury made by young orange worms on green fruits while located under the sepals did not affect the growth and thus cause stunted or pee-wee oranges, nor did it appreciably affect the grade of the fruit.

FACTORS CONCERNED IN THE DEPOSIT OF SPRAYS

II. EFFECT OF ELECTROSTATIC CHARGE UPON THE DEPOSIT OF LEAD ARSENATE

W. M. Hoskins and E. L. Wampler, *University of California, Berkeley*

Introduction.—It has been known for many years that finely divided solids suspended in water or aqueous solutions acquire an electrostatic charge whose sign and intensity is dependent, for the most part, upon the nature of the suspended solid and upon dissolved substances in the liquid. Moore (*10a, b*) showed that leaves are negatively charged when in contact with water and that arsenical insecticides could be prepared which had widely different electrostatic charges when put into water. He obtained some evidence that those which are positively charged are more persistent in adhering to leaves. The promising start made in that work does not appear to have been developed further and, in consequence, it can be said that very little is known concerning the effect of electrostatic charge upon the deposit of insecticides. The present experiments were undertaken to determine how the charge of lead arsenate suspensions is affected by a number of electrolytes and what changes, if any, in the amount of deposit are caused thereby.

Method for determining electrostatic charge of lead arsenate suspen-

sions.—Consideration of the methods which have been used for measuring electrostatic charge, such as coagulation by electrolytes, motion of the interface between a layer of suspension and a layer of water, and movement of individual particles in an electric field, led to choice of the last method as best suited for use with lead arsenate. The apparatus shown in fig. 1 is a microcataphoresis cell modelled after that of Mattson (*8*) but improved in several particulars. The thick-walled capillary tube is 2.5 mm. inside diameter and 12 cm. long. On either end is a section of glass tubing about 1 cm. in diameter. Special care must be taken with the stopcock, for the slightest leak leads to erroneous results. C and D are platinum screen electrodes about .5 cm. square, which are connected with two radio B batteries through a current-reversing switch CR and a key K. The fall in potential in the capillary is determined by connecting a high-resistance galvanometer across the two reference electrodes

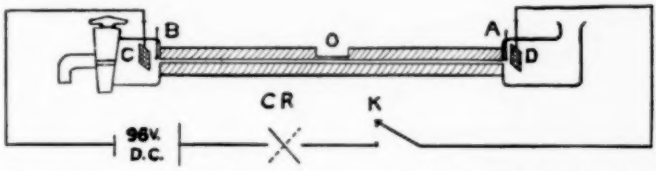


Fig. 1.—Apparatus used for measurement of velocity of migration.

A and B while the cell is filled with any dilute electrolyte. These electrodes are set very close to the ends of the capillary and their distance apart is known (12 cm.). Hence a measurement of the drop in potential between them enables the drop per centimeter, *i.e.*, the potential gradient, to be calculated. This should be done from time to time since the voltage of B batteries sometimes changes. With a potential difference of 96 volts between the electrodes C and D the potential gradient in the capillary is 6.5 volts/cm. This cell can be cleaned by pulling through the capillary a bit of cotton on the end of a fine wire covered with insulation to prevent scratching. Cleaning is especially important when very finely divided solids or oil emulsions are used.

It has been shown, *e.g.* Mattson (*8*), that in a cell of the type described, under the influence of a difference in potential there is movement not only of suspended particles but of the water. It can be calculated and demonstrated experimentally that there is an annular layer distant from the axis of the capillary .707 times the radius in which the water is motionless and in which suspended particles move at their true velocity. In order to simplify observation at this level a flat section, O, was ground into the central portion of the tube until only a thin layer of glass was left above the capillary. With a 16 mm. objective the focal depth was readily adjusted at the correct level by first measuring the diameter of the capillary in terms of the micrometer scale of the microscope and then dropping .293 times the radius from the top of the capillary. With a 10× eyepiece a convenient magnification of 100 was obtained. Illumination was provided from the side through another flat segment in the

capillary wall. A carbon arc light with adjustable diaphragm and water cell for absorption of heat gave a small but intensely lighted region in which particles reflected light at right angles into the microscope lens. The underside of the capillary tube was painted black to provide a dark background, so that the arrangement was actually that of a dark-field ultra-microscope.

The lead arsenate suspensions were prepared by mixing a small amount of the solid with water or with the desired solution of electrolyte. In some cases the lead arsenate was ground in a mortar in order to break up aggregates and in other instances the suspension was allowed to settle for a few minutes and the finer material was then pipetted from the upper liquid and a sufficient volume placed in the cell. It was found that size

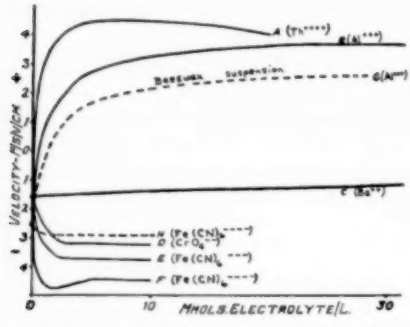


Fig. 2.—Effect of electrolytes upon migration velocity of lead arsenate.

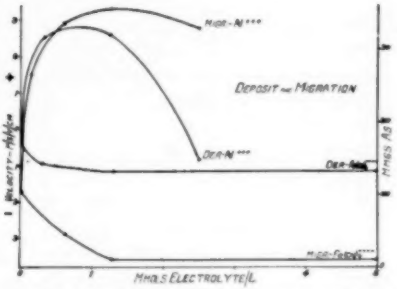


Fig. 3.—Migration and deposit of lead arsenate.

of particle has no appreciable effect upon rate of migration (Abramson, *1*), but it is convenient to use particles small enough so that they do not drop out of the correct level on account of gravity. In cases to be described later in which the spray had first gone through the pump, portions were caught at the nozzle and then put into the cataphoresis cell. Several measurements were made with each suspension and by use of the reversing switch migration was measured in each direction.

The charge upon suspended matter may be expressed as the difference in potential between its surface and a hypothetical layer either at a definite distance away in the liquid or in a zone of appreciable thickness. In either case the calculation of a potential difference is based upon several questionable assumptions (McBain *9*), and it seems better to use the quantity that is capable of precise measurement, *i.e.*, the velocity of migration. This is expressed in terms of microns (10^{-3} mm.) moved per second under a potential gradient of 1 volt per centimeter (μ/s/v/cm). Actual determination of velocity is made by observing by aid of a stop watch the time required for a particle to traverse a fixed known distance on the eyepiece micrometer scale of the microscope under a known potential gradient.

Migration of lead arsenate and the effect of electrolytes.—Samples of C. P. acid lead arsenate and several commercial preparations were first

studied when suspended in distilled water with no electrolyte added. All of these moved toward the positive electrode and at velocities between 1.5 and 2 μ/s/v/cm. This result is in agreement with Moore's (*10a*) conclusion that ordinary lead arsenates bear a negative charge in suspension in pure water. Six salts were then selected to provide ions of widely different valence and their effect at different concentrations upon the migration velocity was determined. The results for the C. P. lead arsenate are given in fig. 2. The commercial products behaved similarly. It is obvious that in the presence of very low concentrations of polyvalent positive ions (Th^{++++} and Al^{+++}) the original negative charge is reduced to zero and then changed to a high positive value, which persists over a range of higher concentrations. Ba^{++} is unable to reduce the negative charge appreciably while the polyvalent negative ions (CrO_4^{--}, $Fe(CN)_6^{---}$, and $Fe(CN)_6^{----}$ increasingly intensify the negative charge in the order given. The results were nearly identical when tap water was used instead of distilled water.

Table 1.—Effect of pH upon migration velocities of suspensions in tap water.

pH	Electrolyte	Velocity in μ/s/v/cm.
	None	
3.5		−1.83
5.5		−1.83
7		−1.83
9		−1.95
	Al^{+++}, 2 millimols per liter	
3.5		+2.60
5.5		+2.60
6.5		+2.14
9		− .91
	$Fe(CN)_6^{----}$ .64 millimols per liter	
3.7		−3.10
4.7		−3.10
6.7		−2.96
9		−2.96

Several of the salts used hydrolyze appreciably and give solutions which are not neutral. Hence the possibility existed that the effects observed were due at least in part to hydrogen or hydroxyl ion. Suspensions containing (a) no electrolyte, (b) Al^{+++} at 2 millimols per liter and (c) $Fe(CN)_6^{----}$ at .64 millimols per liter were varied in pH by addition of .01 N HCl or NaOH and the resulting migration velocities were determined. The results are given in table 1.

It is obvious that little effect is produced in the absence of added electrolyte and in the presence of ferrocyanide ion. With aluminum at pH above 5.5 a decrease in positive charge occurs which leads to a negative charge in alkaline solutions. This effect is first noticeable at the pH at which aluminum ion begins to be removed from solution by hydrolysis to form undissociated $Al(OH)_3$, and it is reasonable to attribute the effects shown in the table to removal of Al ion. This behavior is of no importance in connection with the results to be discussed for in all suspensions in which aluminum ion was present, except those of table 1, the pH was below that at which it has an effect.

Since it was desired to study the effect of strong positive and strong negative electrostatic charges upon the behavior of lead arsenate all further work was done with aluminum or ferrocyanide ions. Thorium ion imparts a stronger charge, but salts of that element are too expensive to be used for any work except small scale laboratory experiments.

Wetting power of electrolyte solutions.—All spraying was done with the pump and other apparatus described in an earlier publication (Hensill & Hoskins *5*). For the reasons stated there a beeswax surface on oil sample bottles was used in the study of wetting and deposit. In a preliminary experiment with a solution containing aluminum ion, unexpected wetting of the wax and formation of a film of solution were observed. This led to a study of the wetting ability of solutions containing aluminum ion or ferrocyanide ion. The wetting power does not become evident until spraying has continued for several seconds. After trials to determine the optimum runoff, 65 cc. was selected. The application of larger volumes causes no appreciable change in the degree of wetting of the various solutions. The presence of lead arsenate has no effect except that when large amounts are present more aluminum ion must be used to produce the same effects.

Table 2.—Effect of Al^{+++} concentration upon degree of wetting.

Concentration of Al^{+++} in millimols per liter	0	.076	.156	.236	.318	.625	.933	1.25	2.50
Degree of Wetting	—	—	—	X	XXXX	XXX	XXX	XXX	—

— signifies no wetting; X signifies that droplets flatten somewhat; XXXX that complete film formation occurs and XXX that there is a slight tendency for the film to recede from small areas. No wetting occurred with any concentration of ferrocyanide ion.

It is thus apparent that over a certain rather narrow range of concentration of aluminum ion ready wetting of the wax surface occurs. This effect is so striking that it seems worthwhile to show the condition by means of a photograph. In fig. 4 the respective concentrations of aluminum ion are (in millimols/1) #4, .076; #5, .625 and #6, 2.50. In considering possible explanations for this behavior it was noted that in the three concentrations of aluminum ion, suspensions of lead arsenate vary in charge from strongly negative through weakly negative or positive to strongly positive. It seemed possible that the wax surface varies similarly and that there is a correlation between charge and ease of wetting. It is difficult to determine the charge upon a large surface of wax, but if the material is finely divided, the determination may be made by observation of individual particles as in the case of lead arsenate. A beeswax suspension was made by dissolving a small amount of the wax in a few cubic centimeters of ethyl alcohol and adding the solution to a large volume of electrolyte solution. The results of migration measurements are shown by the dashed lines of fig. 2. Beeswax in pure water bears a somewhat greater negative charge than acid lead arsenate. The effects of aluminum and ferrocyanide ions are in every way comparable to their effect upon lead arsenate. The significant point is that the wax particles have a low electrostatic charge in the range of aluminum ion concentration at which wetting of the wax surface occurs. Assuming that the wax

surface is affected by aluminum ions in the same manner as the particles of a wax suspension, it follows that the surface is not wet when it is strongly charged either negatively or positively, but that wetting occurs when the charge is low.

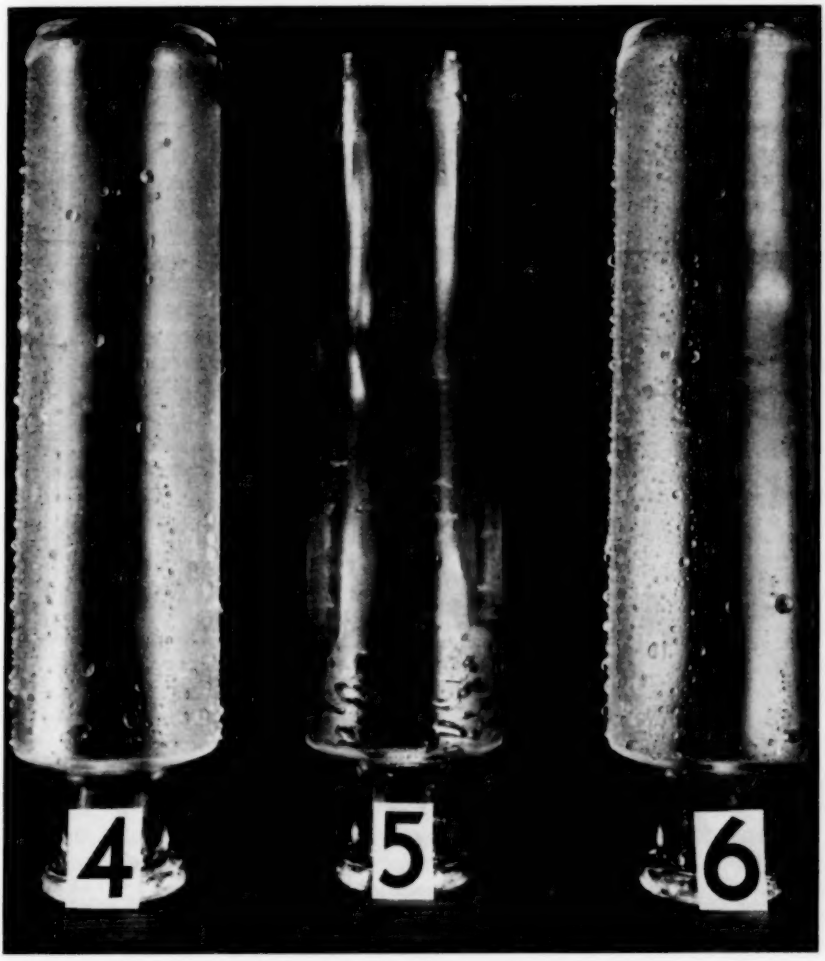


Fig. 4.—Effect of aluminum ion upon wetting. Concentration of aluminum in millimols per liter: No. 4, .076; No. 5, .625; No. 6, 2.50.

Relation between charge of lead arsenate and its deposit.—The deposit of lead arsenate from suspensions containing various concentrations of electrolytes was determined by spraying waxed bottles, removing the deposit with warm 20 per cent hydrochloric acid and determining the arsenic by a modified Gutzeit method (Chauvaud *2*). Two pounds of

commercial lead arsenate were used per hundred gallons. The volume of spray used on each bottle was chosen so that spraying stopped just before a film formed in the case in which wetting occurs most readily, *i.e.*, with intermediate aluminum ion concentration. Fifty-five cubic centimeters per bottle was suitable for the purpose. This procedure gave opportunity for primary deposit to build up to its maximum value and did not introduce the complicating factor of secondary deposit. With the sprays of highest wetting power a few large flat drops formed which were shaken off before analysis was made. The deposit per groups of four bottles, together with rates of migration are shown in fig. 3. The deposit of approximately 180 micrograms of arsenic in the absence of electrolyte was greatly increased by low aluminum ion concentrations. It then reached a maximum and dropped precipitately with further increase of aluminum ion. The range of maximum deposit is somewhat greater than that in which the charge on lead arsenate changes sign and coincides with that in which the charge on the wax suspension changes sign. The variation in amount of deposit can be explained in the following way. In the absence of electrolyte both lead arsenate and wax surface are charged negatively and on account of the repulsion of like charges but little lead arsenate reaches the surface. The addition of

Table 3.—Effect of blood albumin, one-quarter oz. per 100 gallons, upon deposit.

Concentration of Al^{+++}	0	.25	.75	1.25	2.50	5.
Migration Velocity in μ/s/u/cm	−1.40	+ .95	+2.50	+3.	+3.	+2.70
Deposit of As in Micrograms	175	320	420	200	170	140

aluminum ion has a somewhat greater effect upon the lead arsenate than upon the wax surface, both because the latter is originally more negative and because some time is required after spraying starts before the final intensity of charge is reached. Hence with increasing concentrations of aluminum ion both charges are reduced with consequent increase in deposit, then the lead arsenate becomes positively charged while the wax surface is still negative, which is especially favorable for heavy deposit, and lastly, both are strongly charged positively and deposit is greatly reduced. In fig. 3 the corresponding data are shown also for ferrocyanide ion. The increase in negative charge upon both the arsenate and the wax leads to decreased deposit at all concentrations.

Effect of a wetting agent.—The previously described wetting and deposit tests were all made in the absence of any of the ordinary wetting agents. It was important to determine what differences in behavior would be caused by their presence. Two pounds of commercial lead arsenate were used with one-quarter ounce of undiluted blood albumin (*i.e.*, without filler) per hundred gallons of spray. The data are given in table 3. Wetting took place somewhat more rapidly than in the absence of the spreader, but in no case was it complete with the volume used. The migration velocity was very slightly decreased and the maximum deposit occurred at a lower concentration of aluminum ion, but in general the presence of this small amount of blood albumin produced little change.

The above experiment was repeated using blood albumin at the rate

of one ounce to 100 gallons. With this spray wetting occurs when a very small volume has reached the surface, so that it is not possible to obtain only primary deposit. It is of equal interest to study the effect of electrolytes upon secondary deposit, and so spraying was continued after film formation until about 50 cubic centimeters were applied with each concentration of aluminum ion, the latter being used over the same range of concentration as before. This phase of the investigation is being continued but without citing data it may be stated that a much higher aluminum concentration is needed to reverse the charge upon the lead arsenate and the final positive value is somewhat lower than prevails in the absence of the blood albumin. The deposit passes through a maximum at about the same point as when one-fourth ounce of blood albumin is used, but the variation with concentration of electrolyte is greatly decreased. It is probable that a large part of the aluminum is taken up by the albumin and secondary deposit is apparently not so sensitive to electrostatic charge.

Discussion and conclusions.—Lead arsenate resembles most inorganic compounds in possessing a negative charge when suspended in water, and its behavior in solutions of various electrolytes is typical for such substances. The classical work of Ellis (*3*) and Powis (*11a*) showed that even oil droplets are affected similarly by electrolytes. Although calculations of the electrostatic charge upon a suspension are of uncertain accuracy, as previously mentioned, for purposes of comparison with other materials it is of interest to calculate the charge (the so-called zeta potential). Hazel & Ayres (*4*) have shown that the charge in millivolts may be found by multiplying the migration rate in μ/s/v/cm. by 14. Hence a commercial lead arsenate which moves with a velocity of -1.76 μ/s/v/cm. bears a negative charge of 24.6 millivolts. This is slightly below the minimum charge of 30 millivolts found by Powis (*11b*) to be necessary to ensure the stability of an oil emulsion. This is in agreement with the observed fact that lead arsenate suspensions are completely precipitated after an interval of a few hours. On the other hand the highest migration velocity imparted by aluminum ions was found to be 3.7 μ/s/v/cm., corresponding to a charge of nearly 52 millivolts and such suspensions are stable for long periods. In the range of zero charge the lead arsenate is precipitated in a few minutes.

Water used in spraying seldom contains appreciable amounts of tri or tetravalent positive ions, though iron is occasionally found, but divalent negative ions such as sulfate and carbonate occur often. These increase the negative charge of the lead arsenate and thus decrease deposit. It has been found by many workers that hydrogen and hydroxyl ions have a significant effect in the absence of polyvalent ions. This effect may be exerted not only upon the spray material but upon the surface sprayed and upon the wetting agent used, for the adsorption of such amphoteric substances as proteins is influenced by hydrogen ion concentration (Martin *7*). Hence, it is very probable that the variations in pH which are found in natural waters affect deposit. This point is being investigated. The possibility of a surface changing intensity or sign of its charge while being sprayed does not appear to have been noted by previ-

ous workers. Since different surfaces, *e.g.*, leaves, twigs, fruits, are of widely divergent composition, it is obvious that the greatest variety of reactions to sprays may be expected. Unfortunately, no theoretical basis for relating charge with wetting seems to be available. It does not seem possible to apply the ordinary relation regarding surface and interfacial tensions, for interacial tension, which should be low for wetting to occur, has been found to be of maximum value with an uncharged mercury-water interface (Kruyt *6*). This condition may not hold, however, for the interface between water and a nonreactive substance such as wax. Important information on this problem may be obtained by determining the charge on leaves and fruit surfaces in the presence of electrolytes, preferably by the electro-endosmosis method used by Moore (*10a*).

The small effect of electrostatic charge upon secondary deposit of lead arsenate is probably of little practical significance, for only a very small amount of spray material is deposited in that way. The present studies were made with undiluted blood albumin, and it was noted that sprays containing that material have much greater wetting power than do those containing the same amount of albumin, but diluted with filler as in the commercial preparation. The effect of electrostatic charge upon deposit in the presence of commercial wetting agents is being investigated.

Summary.—A microcataphoresis cell for the determination of the electrostatic charge of suspensions is described and figured. Suspensions of acid lead arsenate in water have a negative charge. Very low concentrations of polyvalent positive ions, *e.g.*, Al^{+++}, decrease this charge and higher concentrations give a strong positive charge to the suspension. Beeswax suspensions act similarly to lead arsenate. Solutions containing aluminum ion in the concentration range which gives little or no charge to particles of wax in suspension, wet a surface of the same kind of wax. The deposit of lead arsenate varies with the concentration of aluminum present. It is increased by concentrations which give a low positive charge to the lead arsenate and leave a negative charge on the wax surface, but it is greatly diminished when both the lead arsenate and the wax are positively charged. The effect of wetting agents upon this effect is dependent upon the amount used.

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COMPARISON OF CRITERIA OF SUSCEPTIBILITY IN THE RESPONSE OF *DROSOPHILA* TO HYDROCYANIC ACID GAS

II. RECOVERY TIME

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In the preceding paper (*2*) the susceptibility of adult *Drosophila melanogaster* Meigen was related to the concentration of hydrocyanic acid gas and to the length of the exposure period when susceptibility was measured by stupefaction time and by the percentage of mortality. By timing the recovery from paralysis due to hydrocyanic acid in the same experiments, the reaction of *Drosophila* to the poison has been studied by means of an additional criterion of susceptibility. The present paper deals with the toxicological information that has been obtained with this technique.

Measurement of recovery time.—In these experiments the recovery period has been defined as the interval between the end of fumigation and the first appearance of coordinated movement, when the flies were kept in still air in small glass tubes from which the residual hydrocyanic acid gas had been removed by suction (or occasionally by compressed air) immediately after treatment. The effect of not removing the residual gas was tested on August 24, when, after a two-minute exposure to .99 mg. of hydrocyanic acid per liter, the gas was flushed out in one case but not in another. In the presence of residual gas 316 minutes was required for 50 per cent of the flies to recover as compared with 62 minutes when this gas was removed.

As with the other criteria of susceptibility, it was desirable that a function of time be chosen such that the variation between individual flies in the length of their recovery period would be symmetrically and

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normally distributed. This was true when the minutes required for recovery were first converted to logarithms. In the experiment on October 19, described previously (*2*), 69 flies were exposed for one minute to the gas at a concentration of 1.20–1.22 mg. per liter. All individuals recovered from the fumigation and all but three of them were alive 24 hours after

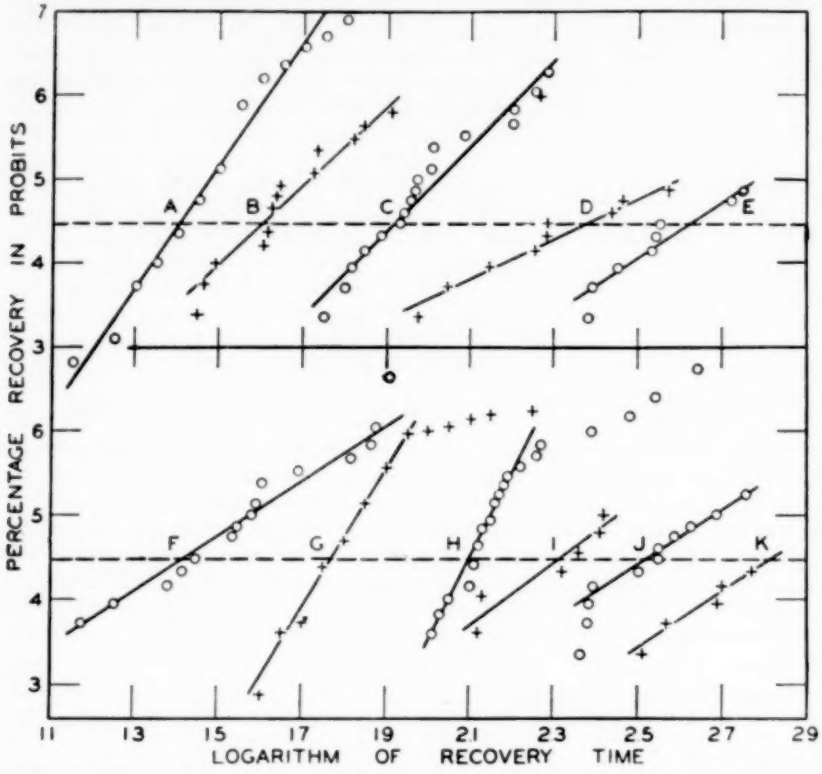

Fig. 1.—Rate of recovery of adult *Drosophila melanogaster* from the paralysis caused by sublethal doses of hydrocyanic acid. Curve A, based on grouped data, has been fitted arithmetically by computing the mean and standard deviation; the other curves have been fitted without computation. Thirty per cent recovery has been indicated by the broken horizontal line. The date of fumigation, the length of exposure in minutes, and the concentration of hydrocyanic acid in milligrams per liter for each curve were as follows:

Curve	Date	Min.	Concn.	Curve	Date	Min.	Concn.	Curve	Date	Min.	Concn.
A	Oct. 19	1	1.22	E	Apr. 2	19	1.23	I	May 4	5	1.95
B	Nov. 22	2	1.09	F	Oct. 31	2	.90	J	Oct. 31	9	.90
C	Nov. 22	4	1.09	G	May 28	2	.98	K	Mar. 28	15	1.55
D	Nov. 22	8	1.09	H	Mar. 22	8	1.10				

treatment. The data for the males have been combined with those for the females, since a comparison of the recovery periods showed that their reactions to cyanide fumigation did not differ significantly. When the number of individuals that recovered in each interval of time was plotted against minutes directly, the frequency distribution was signifi-

cantly asymmetrical, but when plotted against the logarithm of the number of minutes (grouping in logarithmic class intervals of .03 instead of in direct arithmetic intervals of three minutes), the flies were distributed symmetrically and approximately normally, fig. 1, curve A. The statistics for these two methods of handling the same data are:

	Minutes	Logarithms of Minutes
Mean recovery time	31.391±1.369	1.4776±.0162
Standard deviation	11.372± .991	.1349±.0117
Measure of asymmetry, g_1	2.230± .289	.156± .289

In most of our experiments fewer individuals than in the foregoing test were given the same treatment and a varying proportion failed to make any recovery whatever. Often it was not possible to observe the time of recovery continuously or at equal intervals. The original data, therefore, represented essentially cumulative frequency distributions in that the number or percentage of flies that had recovered at any recorded time was known with greater precision than the time at which each fly showed its first coordinated movement. Statistically, our original observations represented skewed, truncated, cumulative frequency distributions with unequal grouping, a form of distribution which it was more practicable to solve by graphic methods than by direct computation. Each experiment, consisting usually of 10 or 20 flies fumigated simultaneously—or, in a few cases, in several successive fumigations of two flies each—was handled separately. The percentage of flies that had recovered at each recorded recovery period was then computed and the percentages were converted to probits and the minutes to logarithms. By plotting probits against logarithms, it was possible to fit the recovery data for each test with a straight line in accordance with the hypothesis underlying the analysis of the foregoing experiment. For statistical reasons which will be considered elsewhere, these lines tended to underestimate the survival time to the extent to which the recorded recovery times coincided with the actual recovery times, but this small, relatively constant bias did not vitiate the comparative value of the analysis that has been based upon them. In all, 118 experiments were analyzed, of which a few examples are shown in fig. 1.

Although in most experiments some of the flies never recovered from the fumigation, these dead individuals were included in determining the percentages of recovery, for several reasons. The variation in susceptibility has been shown to be continuous and normal for the entire population by criteria such as the dosage-mortality curves, the preparalytic period, and the recovery period itself when all the flies recovered. Since the individuals that failed to recover presumably were more susceptible to hydrocyanic acid poisoning than those that did recover, an "average recovery time" which ignored those that were killed outright should only be compared with the "average recovery times" of other experiments in which there was the same percentage of survivors. When the percentage of recovery in the present tests was based upon all treated flies, given percentages of recovery represented equivalent levels of resistance (or susceptibility), even though 95 per cent of the flies may have recovered in one experiment and only 50 per cent in a second. The fact that the ex-

periments plotted in fig. 1 could be fitted by straight lines supported this interpretation.

There was not always a sharp break, however, between flies that either recovered "on schedule" or did not recover at all. In 30 of the 118 experiments the last few flies in a series to recover did so much more slowly than would be expected from a curve based upon those that recovered more quickly. Apparently in individuals with a susceptibility such that recovery was just possible, the inactivation of the adsorbed poison involved other and slower reactions than those that sufficed in more resistant individuals. When the recovery time for these borderline individuals was such that they could be separated from the rest of the flies in the test, they have been excluded in placing the recovery curves, fig. 1, curves B, G and H. But in some cases, especially at the higher dosages from which the proportionate recovery was small, these ordinarily secondary reactions of recovery may have been involved in most of the survivors and increased the variation in susceptibility, as shown by a flattening of the main curve.

Relation of recovery time to dosage.—In order to relate recovery time to the two primary elements of dosage, concentration of hydrocyanic acid and length of fumigation, the logarithm of the number of minutes within which 30 per cent of the flies had recovered was adopted as the standard. Several advantages determined the adoption of this relatively early period in recovery. Experiments could be included from which there was less than 50 per cent survival, fig. 1, curves D, E and K. The primary reaction of recovery was the limiting factor when a secondary stage was present and could be distinguished. In 19 of the tests the first or the first few flies to recover were delayed beyond the time expected on the basis of the majority of the survivors from the test, possibly an experimental error, fig. 1, curve J. These discrepant individuals were disregarded in adjusting the straight lines to the observations of each experiment, and in all cases the probit value for 30 per cent recovery (4.476, shown by a horizontal broken line in fig. 1) was above the range of this error. A few tests have been included in which less than 30 per cent of the flies recovered, and in these cases the time equivalent to a recovery of 30 per cent has been determined by extrapolation, fig. 1, curve K.

Since the estimates of recovery time differed greatly in their accuracy, each one was weighted in proportion to its reliability. The reliability of a mean is directly proportional to the reciprocal of its variance, or to the number of observations divided by the square of the standard deviation. This was also the best available measure for the reliability of the interpolated log-time values for 30 per cent recovery. The standard deviation was read directly from each curve as the difference on the abscissa (logarithm of minutes) of two points separated on the ordinate by one probit. As the number of observations we used the total number of flies in the test when the curve was based upon all the surviving flies. When plotted points were excluded in drawing the recovery curve, the number of observations was reduced correspondingly, and if these excluded cases were at the upper end of the curve the nonsurvivors were also excluded from the weighting factor. By this system of weighting the value of the

118 separate determinations ranged from .2 to 69.3 weighting units.

On the foregoing basis, recovery time could be analyzed in terms of three independent variables, the logarithm of the length of exposure in minutes, the logarithm of the concentration in milligrams per liter, and the mean temperature in degrees Centigrade. The temperature seldom varied as much as 2° C during the observations on any one day, but was recorded for only 77 out of the 118 tests. Experiments for which all the independent variables had been recorded were analyzed as a separate group, in order to determine whether within a range of 22–28° C tem-

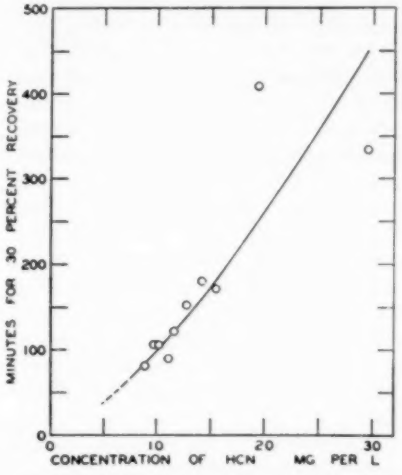

Fig. 2.—Net effect of the concentration of fumigant upon the time required for 30 per cent of adult *Drosophila melanogaster* to recover from paralysis after an average fumigation period of 4.5 minutes.

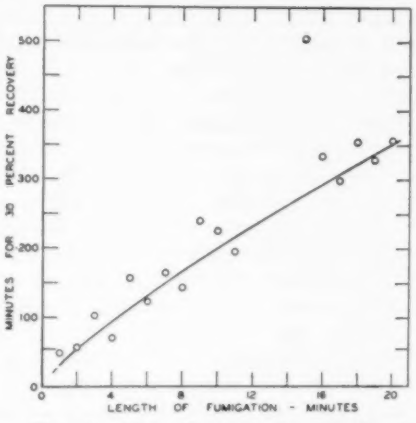

Fig. 3.—Net effect of the length of fumigation upon the time required for 30 per cent recovery from paralysis of adult *Drosophila melanogaster* when the concentration of hydrocyanic acid was 1.035 mg. per liter.

perature had had any net effect upon recovery time after allowing for the two dosage characteristics, length of exposure and concentration. Since the statistic by which this effect was measured (the partial regression coefficient) proved to be smaller than its standard error ($-.0003 \pm .0098$), it was evident that under the conditions of the present experiments differences in temperature could be ignored.

The next step in the analysis was to determine the relation between recovery time and the two components of dosage, the concentration and the time of exposure. This relation was determined only from those experiments in which one or more flies had failed to recover. Although this selection reduced the number of experimental series from 118 to 94, it made possible a later comparison of the variance of the two criteria of toxicological response, percentage mortality (in probits) and recovery time (in logarithms). By computing the multiple regression equation, the logarithm of the time in minutes (X) for 30 per cent of the flies to recover from a partly lethal fumigation could be expressed in terms of

the concentration (C) and of the length of fumigation (t) by the equation

$$X = 2.0164 + 1.399(\log C - .0148) + 0.813(\log t - .6536).$$

In order to show how well this equation for the net effect of the two components of dosage upon recovery time agreed with the experimental observations, the data were plotted in two diagrams by the following method: The expected recovery time for each of the 94 experiments was computed by the above equation from the observed concentration and length of exposure, the differences between the observed and the expected recovery times were averaged for each concentration and for each fumigation period, and the average differences were then plotted about the two straight lines given by the equation. These results have been converted from logarithms to the original units of milligrams of hydrocyanic acid and minutes and plotted in figs. 2 and 3. Figure 2 shows the effect of the concentration of hydrocyanic acid upon the time required for 30 per cent recovery when the fumigation period was held constant at its average of 4.50 minutes. Figure 3 shows how the time to effect the same recovery was determined by the length of treatment when the concentration was constant at its mean of 1.035 mg. per liter.

The equation giving the length of the recovery interval in terms of concentration (C) and fumigation time (t) has been transformed to show the relation between C and t for a constant toxicological response or recovery interval. Similar equations were determined for alternative criteria of toxicity in the preceding paper (*2*). In order that they could be compared, the time for 30 per cent recovery has been computed for a concentration of hydrocyanic acid and a length of treatment that would kill 50 per cent of the flies, as given by the equation $C^{1.9}t = 10.2$, and at the same time approximate the average concentration (1.035 mg. per liter) and the average exposure time (4.5 minutes) for the recovery data. These conditions were fulfilled at a concentration of 1.259 mg. per liter for 6.56 minutes, from which dosage 30 per cent of the flies would be expected to recover in 186 minutes. Substituting the logarithm of 186 (2.2696) in the regression equation above, we find that concentration and time of exposure were related as $C^{1.7}t = 9.8$, when the recovery period was used as the criterion of susceptibility. This may be compared with the equation $C^{1.9}t = 10.2$ that was determined from the concentration-mortality curves in the preceding paper (*2*). At 50 per cent mortality the two equations relating concentration and length of exposure were in substantial agreement, although computed by two different criteria of susceptibility (or toxicity) in part from different experimental series. The length of the period of recovery from a sublethal dose and the percentage of immediate mortality measured approximately the same proportion of the hydrocyanic acid fixed by the cell during fumigation; it should therefore be possible to substitute one criterion for the other.

The value of recovery time as a toxicological index depended upon whether its accuracy equaled or exceeded that shown by the percentage of mortality. Since the experiments used in analyzing recovery time were restricted to those in which three or more flies recovered and at least one

fly died, this series could be used for a comparison of the accuracy of the two indices. The mortality in each of the 94 experiments (which ranged from 4 to 85 per cent dead) was converted to probit units (Y), which were then related to the concentration (C) and to the length of fumigation (t) by calculating the multiple regression equation:

$$Y = 4.631 + 3.226(\log C - .0436) + 1.076(\log t - .7175).$$

In the computation of this equation the different experiments did not have the same relative weights as in the computation of the equivalent equation for 30 per cent recovery time. Here they were based necessarily upon the observed mortality in probits, a procedure that tended to overweight errors in the direction of 50 per cent mortality (*1*). More important than this bias was the fact that the equation was calculated from a series of experiments selected on the basis of the dependent variable so that the higher mortalities were omitted. Therefore, it was not a valid estimate of the relation between concentration and time in the poisoning of *Drosophila*. The method of selection, however, since it was not dependent upon recovery time, did not bias our previous estimate of the recovery interval or prevent our using the present estimate of probit mortality for a comparison of the accuracy of the two indices.

The reliability or accuracy of the two measures of susceptibility was proportional to the extent to which the variability in each could be accounted for by the conditions of the experiment. In the present case there were 94 determinations of the logarithm of the time for 30 per cent recovery (X) and 94 parallel determinations of the mortality in probits (Y). From the two series of determinations it was possible to compute an average logarithm (2.0164), an average probit (4.631), and the total (weighted) variance about each of these two means (39.441 and 409.532, respectively). Since the dosage varied in the different tests, the average effect of the concentration of hydrocyanic acid and of the length of treatment upon X and Y has been expressed in the two multiple regression equations already given. Differences in the recorded dosage, therefore, contributed to the total variance in X and Y amounts equal to 30.622 and 180.932, respectively. The difference between each total variance and that part of the variance contributed by dissimilarities in treatment represented a residual error, the inaccuracy in the determination. In the present case the residual error in X was only 22.4 per cent of the total variance of X, and the residual error in Y 55.8 per cent of the total variance of Y. Recovery time was here a much more sensitive index to the degree of poisoning than was the customary percentage of kill.

After the measurable effect of dosage was eliminated, the higher mortalities were found to be correlated significantly with the longer recovery intervals. A correlation coefficient of .72 has been computed from the residual errors in an analysis based upon weights appropriate for the recovery interval. This correlation resulted in part from the fact that each estimate of recovery time was based upon all the flies in the test, including those that did not recover, and in consequence indirectly measured the mortality. Some of it, however, was probably due to variations in the amount of poison adsorbed, which were not accounted for by the

recorded concentration of hydrocyanic acid and the length of exposure, being reflected in both recovery time and percentage of mortality, a fact which increased the validity of recovery time as a toxicological measure.

Effect of age of flies upon susceptibility.—When the effect of age upon susceptibility was measured by means of the recovery time, flies that were from two to six weeks old proved to be more susceptible than the young flies that were standard for these experiments. The tests in which flies of two different known ages were fumigated either in successive treatments (May 14) or in alternate positions in the tubes of a single treatment (October 17 and 24) have been summarized in table 1 from graphic interpolation. The significance of each comparison is shown by the statistical constants in the last two columns. In all five cases the older flies were slower in effecting a 50 per cent recovery than the younger individuals, although in only two of these was the difference statistically significant.

Table 1.—Effect of age of adult *Drosophila melanogaster* upon the time required (in logarithms) for 50 per cent to recover from paralysis due to fumigation with hydrocyanic acid gas.

Date	Dosage		Flies		Age,	Logarithm of Recovery Time		Comparison	
Treated	Concentration, mg. per liter	Exposure minutes	Total no.	No. recovered	Days	Median	Standard deviation	t	n
May 14	.52	2	20	20	1	1.85	.12	4.29	38
			20	14	14	2.10	.14		
Oct. 17	1.05	2	10	8	1	2.29	.44	.58	18
			10	8	33–34	2.43	.31		
Oct. 24	1	4	20	17	2–5	1.92	.18	2.88	37
			19	16	33	2.13	.14		
		2	20	19	2–5	1.74	.17	1.52	38
			20	20	33	1.84	.12		
		2	10	10	2–5	1.66	.17	1.17	18
			10	9	41	1.85	.32		

Comparisons of Recovery Time with Other Criteria of Susceptibility in Individual Flies

Up to this point comparisons between the different criteria of susceptibility have been based upon the response of a group of flies by one standard compared with the response of the same group by an alternative one. This comparison has been carried a step further to determine whether the individual flies within an experimental series tended to keep the same positions relative to one another when classified by more than one criterion. The extent to which such relative positions were maintained indicated how nearly they may have represented the same basic physiological response. In the present preliminary experiments these comparions were all based upon the length of the recovery interval (in logarithms), with which we have compared stupefaction time, length of the survival period following recovery, and the recovery interval after a second treatment.

Relation between stupefaction and recovery.—This was measured in two experiments in which both stupefaction and recovery were timed for each fly, two flies being exposed at a time. In the first experiment the concentration of hydrocyanic acid exceeded 1.6 mg. per liter but was not measured. The flies were removed from the gas as soon as both were stupefied; the length of the fumigation was therefore determined by the

stupefaction time of the less susceptible fly in each pair. For correlation with the length of the recovery interval only the individual that was paralyzed last was used, except when they succumbed at the same time or within one second. The mean stupefaction (and exposure) time for 74 flies was $.303 \pm .008$ minute, and the mean recovery interval 30.0 ± 1.8 minutes, or approximately 100 times as long as the poisoning phase. The correlation between the minutes for stupefaction and for recovery (in logarithms) did not differ significantly from zero ($r = .068$).

In the second experiment each pair of flies was exposed for one minute to the gas at a concentration of 1.22 mg. per liter. The mean stupefaction time for 137 flies was $.402 \pm .006$ minute and the mean recovery time $29.53 \pm .90$ minutes. Although the correlation between the two indices was small ($r = .201$), it was significant ($P = .02$), indicating that the longer a fly resisted the paralyzing action of hydrocyanic acid, the earlier was its subsequent recovery.

The following explanations of these experiments have been suggested. If stupefaction were determined by the fixation within a fly of a physiologically constant amount of cyanide, its time of recovery from a dose so adjusted to its individual susceptibility (to its stupefaction time) would not be determined by that susceptibility, as was in fact observed. With a uniform exposure of one minute, however, the more susceptible individuals, as judged by their earlier stupefaction time, required a longer time to recover either because they adsorbed more cyanide than the less susceptible flies or because their rate of recovery was slower. The small observed correlation was consistent with the difference in the equations relating time and concentration, $C^{.8}t = .47$ for stupefaction and $C^{1.7}t = 9.8$ for recovery. Because of the high concentration of hydrocyanic acid, stupefaction in the first experiment occurred in the minimum time. This minimum period probably represented the time required for a stupefying dose to diffuse into the fly regardless of the concentration, and may therefore have been controlled by morphological characteristics other than the physiological condition of the absorbing cells. If the latter determined the recovery time, stupefaction and recovery at a high concentration would have been controlled by different mechanisms, and in consequence not correlated. At lower concentrations, as in the second experiment, when stupefaction presumably was determined by the rate of adsorption in the sensitive tissues, there would have been a physical basis for the observed negative correlation between stupefaction and recovery times.

An alternative hypothesis, that the minimum stupefaction time represented primarily the time for a rapidly adsorbed dose to produce its effect internally, was eliminated by the absence of a positive correlation between stupefaction and recovery. In experiments upon young *Limnoria*, Shackell (*4*) observed a high positive correlation (.93) between the paralytic and the recovery periods when the larvae were removed immediately after paralysis in a .5 per cent solution of phenol to fresh sea water. The marked difference between Shackell's results and those observed here could be understood if the time to paralyze in *Limnoria* had been due primarily to a latent period between the fixation of a

paralytic dose and its external expression. If this were the case, the longer the latent period the more excess phenol would have been adsorbed and the longer would have been the recovery period required for its inactivation. We may conclude from these experiments that comparisons of insecticides on the basis of their preparalytic periods alone may have only an indirect bearing upon their relative final effectiveness.

Relation between percentage of partial recovery and recovery time.—The flies that recovered from paralysis could be separated into two groups, those in which the recovery was partial and followed within a day or two by death and those in which recovery was nearly complete. On 13 days between March 27 and October 31, the experiments included sufficient flies in each category and a wide enough range of recovery

Table 2.—Partial recovery (delayed mortality) in relation to recovery time in *Drosophila melanogaster*[3].

Logarithm of Recovery Time	Number of Flies Recovering in Time Indicated									
	Series I		Series II		Series III		Series IV		Series V	
	Total	*P.R.*	*Total*	*P.R.*	*Total*	*P.R.*	*Total*	*P.R.*	*Total*	*P.R.*
1.30–1.39	2		3				9	3		
1.40–1.49	1		3				9		8	4
1.50–1.59	3	1	9		2		20	4	2	1
1.60–1.69	10	1	22	1	4		27	6	27	17
1.70–1.79	17	5	28	4	10		46	7	19	16
1.80–1.89	15	6	37	5	5		41	10	18	10
1.90–1.99	8	6	34	8	14		16	5	7	4
2.00–2.09	2	1	49	15	9		4	1	11	5
2.10–2.19	5	4	62	17	6		2		15	12
2.20–2.29	5	5	47	21	12		2		16	12
2.30–2.39			43	27	16	3			18	12
2.40–2.49	1	1	23	19	17	4			8	3
2.50–2.59	1	1	23	20	30	14			5	3
2.60–2.69			7	7	7	6			2	2
2.70–2.79			10	9	9	7				
2.80–2.89			1	1	1	1				

times to be suitable for testing the relation between these criteria. Since the logarithm of its recovery time measured the extent of poisoning in the individual fly, the flies from each day's experiment were grouped by this index without reference to either the concentration of hydrocyanic acid or the length of treatment. Each fly was classified as having made either a complete or a partial recovery, and the percentage of partial recovery was computed for each interval of recovery time. When these percentages were plotted against the logarithm of the recovery time, on all but two or three days a sigmoid curve was obtained similar to the typical dosage-mortality curve, the flies that recovered in the shortest time recovering completely and those that recovered the most slowly dying within a day or two. The data from 11 of the 13 days have been combined into five representative series in table 2 and studied statistically.

The relation between the percentage of partial recovery and the recovery time varied considerably. In two series (IV and V) the two indices were independent of each other, there being the same percentage of partial recovery within a series, as judged by the χ^2 test, when the recovery period was short as when it was long. In series IV, 20.5 per cent of 176

[3] The total number of flies includes all individuals that recovered at all from initial paralysis; those in which this recovery was only partial (P.R.) died within two days. The various series were fumigated on the following dates: I, Oct. 24; II, May 14 and 16, Aug. 17 and 24, Oct. 31; III, Apr. 2, Aug. 23, Oct. 17; IV, May 28; V, Aug. 8.

flies recovered only partially, and in series V, 64.7 per cent of 156 flies. In the remaining three series the percentage of partial recovery was converted to probits, and when plotted against the logarithm of the recovery time the observations could be fitted by straight lines with which they were in agreement as tested by χ^2. Accordingly the partial recovery (or delayed mortality) in probits was directly proportional to the logarithm of the recovery time. The calculated curves and the observations have been plotted in the original units of minutes and percentages in fig. 4. The three series varied both in respect to the mortality (or percentage of partial recovery) which followed a given recovery time and independently in the rate at which a change in the time modified the mortality in each case. In the first three series recovery periods of 77,

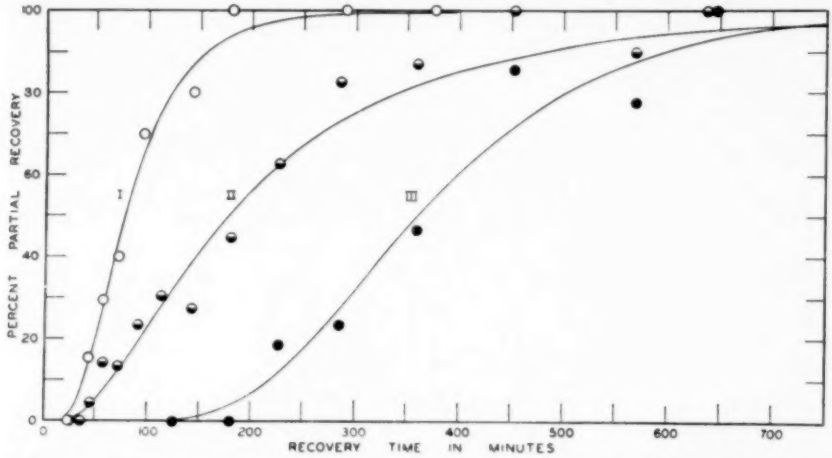

Fig. 4.—Relation between the percentage of partial recovery and degree of poisoning of adult *Drosophila melanogaster* as indicated by the time required for recovery from paralysis. Data from table 2.

176 and 360 minutes, respectively, were followed by 50 per cent delayed mortality. A given increase in the amount of poisoning as measured by the logarithm of the recovery time caused relatively the same increase in mortality in series I and III, but less than 70 per cent as large an increase in the mortality of series II. The experiments indicate that the change in mortality from its initial determination at the time of maximum recovery to its second determination a day or two later depended in part upon post-treatment conditions. The relation between recovery time and percentage of partial recovery may be a sensitive biological measure of these conditions.

If recovery from fumigation were really complete, there should have been no correlation between a criterion of susceptibility or poisoning, such as the recovery time, and length of life, after the individuals that recovered only partially had been omitted. This has been tested with two of the above results, those on April 2 (included in series III) and those on May 28 (series IV). In the first instance the correlation coefficient be-

tween the logarithm of recovery time and the length of life was −.160 for 37 flies and in the second case it was −.063 for 22 flies. Neither coefficient differed significantly from zero, although both were negative, as would be expected if the effect of treatment persisted beyond the two-day limit that has been set for incomplete recovery. In numerous tests on the fertility of fumigated flies that recovered completely after both long and short periods of paralysis, their fecundity appeared to be normal.

Correlation of recovery times from two successive treatments.—The relative susceptibility of individual flies as measured by the recovery time from one fumigation persisted, at least in part, until a second fumigation on the following day. In the first attempt to measure this, on May 28 and 29 all flies were fumigated for two minutes at concentrations of .91 and .86 mg. per liter, respectively. The recovery time from the first treatment was correlated with that from the second treatment (both in logarithms) in two series of 20 and 18 flies, respectively. Neither of the correlation coefficients (.23 and −.09) was significant. Since there were several indications of unreliability in this record, the experiment was repeated on August 23 and 24, with concentrations of 1.01 and .99 mg. per liter, respectively, for separate fumigations of six, four, two and two minutes. The correlation between the logarithms of recovery time from the first and the second treatments was computed separately for each group, and the correlation coefficients were .61, .21, .69, and .59. These coefficients for a total of 50 flies were combined by Fisher's z method (*3*) into a single coefficient of .529, which was statistically significant. These experiments were purely exploratory, but they indicate that at least part of the difference in susceptibility from one fly to another in the population may have been a constant individual characteristic. The first fumigation did not render the flies more susceptible to a second one, since the time required for 50 per cent recovery from the second treatment was in no case longer than that from the first treatment.

Summary

The time of recovery from paralysis due to fumigation with hydrocyanic acid has been compared with other toxicological indices in adult *Drosophila melanogaster* Meigen. Since the logarithms of this period were distributed symmetrically and normally in an experiment in which all the flies recovered, the recovery time has been expressed in logarithms for purposes of analysis. In most tests some flies failed to recover, but by means of a graphic method, which is described, it was possible to treat all experiments on a common basis. The straight lines relating percentage recovery (in probits) and recovery time (in logarithms) were usually in satisfactory agreement with the observations over the entire range of recovery times. In some cases the last flies to recover were delayed beyond the time expected from the curve, a trend which suggested that their slower rate of recovery was limited by secondary physiological reactions. The logarithm of the time for 30 per cent recovery (X) has been determined by graphic interpolation and then correlated with the concentration of hydrocyanic acid (C) and the exposure period in minutes

(t). For 94 experiments in which mortality ranged from four to 85 per cent kill, the relation could be expressed satisfactorily by the partial regression equation

$$X = 2.0164 + 1.399(\log C - .0148) + .813(\log t - .6536).$$

As computed from this equation, 30 per cent of the flies recovered in 186 minutes from a median lethal dose of 1.26 mg. of hydrocyanic acid per liter for 6.56 minutes. By substituting the logarithm of 186 for X in the regression equation, it could be reduced to the form $C^{1.7}t = 9.8$. Because of its similarity to that derived for 50 per cent kill from the concentration-mortality curves, both relations were assumed to measure the same toxicological process. An analysis of the variance of these two indices of toxicological response showed that the recovery interval was a more precise measure of poisoning than the percentage killed.

Several criteria of susceptibility have been compared in individual flies. The correlation between stupefaction and recovery time was consistent with that expected from the experimental conditions, in one case being zero and in the other small ($r = -.201$) but significant, and indicating that individuals that succumbed more quickly to the gas usually required a longer time for recovery. In most cases the percentage of incomplete recovery increased with the length of time required to recover, although sometimes the two criteria were quite independent. When not independent, the delayed mortality in probits was directly proportional to the logarithm of the recovery interval, but the percentage of flies that died within two days after recovering at a given time varied from one experiment to another. In three groups of tests recovery periods of 77, 176 and 360 minutes, respectively, were followed by 50 per cent mortality. In 50 flies that survived fumigation on two successive days, the logarithm of the time to recover from the first treatment was correlated with the logarithm of the time to recover from the second treatment. The correlation coefficient of .529 indicated that at least in part the variation in susceptibility was static, so that individuals judged in reference to their susceptibility by one test would be similarly classified in a second test.

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NOTES ON THE CONTROL OF *ANARSIA LINEATELLA* IN CALIFORNIA

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During the season of 1932 preliminary tests of the efficacy of several types of control programs in reducing populations of the peach twig-borer *Anarsia lineatella* Zeller (Lepidoptera, family Gelechiidae), in peaches were conducted in Sutter county, Calif., by the State Department of Agriculture. Some of the results of these experiments are summarized in this paper.

All of the measures employed in efforts to control the peach twig-borer on peaches in the Sacramento valley are applied either in the spring against the larvae emerging from hibernation, or in early summer when the first summer brood appears. The programs which we observed to be the most commonly used by growers may be described as follows:

(1) Sprays of lime sulfur solution, six or seven gallons to 100 gallons of water, applied from the time when blossom buds show pink until blossoming begins. This program is probably the least depended upon at present, although it was formerly the standard recommendation. Its popularity may have been attributable partially to the fact that the material is considered to be also of fungicidal value.

(2) Applications of the above described material to which has been added basic lead arsenate, three pounds to 100 gallons of spray, and applied at the same time.

(3) The use of basic lead arsenate, three pounds to 100 gallons of water, applied later, usually following the blooming period. To this material small amounts of lime sulfur, three gallons or less to 100 gallons of spray, are often added.

(4) Applications of basic lead arsenate as a spray or dust when the larvae of the first summer generation are feeding, which is normally in May or June. This treatment, which follows the others mentioned by two months or longer, has been the only one employed in some instances, but is often used in addition to one of the other procedures.

Adequate experimental data regarding the respective efficacy of each of these treatments have not been secured under present conditions of peach culture. The experiments summarized here were limited in scope, and should be considered of a preliminary nature. In the light of present knowledge the best recommendation appears to be the use of basic lead arsenate, three pounds to 100 gallons of water, plus a suitable spreader. The time of application favored is just following the blossoming period. It is not often possible to cover a large acreage at exactly this stage, but the application should be completed 10 to 15 days after the peak of full bloom before the larvae of the current generation may be expected to have begun to pupate. In timing the application of this spray

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to secure a coverage when the greatest number of the overwintering larvae are feeding, dependence may be placed in orchard inspections.

Spring Control Experiment, 1932

Experiment I.—A test of lime sulfur solution and basic lead arsenate was made on one-year-old, second-growth peach shoots growing from the stumps of trees cut down the year previous. The growth used was about four feet high, bearing normal leaf buds and blossoms. The shoots were not all of similar type, having sprung from the root stocks, but those selected for spraying were blooming at approximately the same time. Thus the treated trees were located at random over a one-acre portion of the orchard. The trees were all observed to bear large numbers of hibernaculae, but no determination was made of the initial population of borer larvae on each tree. For this reason the summarized results show larger infestations present on some treated trees than on untreated trees, ascribable without doubt to the presence of higher populations before treatment.

Table 1.—Spring control experiment, 1932.

Material, and Concentration per 100 Gals.	Trees Counted	Total Leaf Buds and Blossoms Counted	Total Live Larvae Found	Per cent Infested	Per cent Control
Lime sulfur solution, 6 gals.	3	5468	40	.73	−22
Lime sulfur solution, 9 gals.	3	6814	24	.35	42
Lime sulfur solution, 6 gals+ Basic lead arsenate, 3 lbs.	3	5693	1	.02	97
Basic lead arsenate, 3 lbs.	3	4274	0		100
Basic lead arsenate, 3 lbs.*	3	3985	0		100
Check, no treatment	3	4659	28	.60	

* Treatment applied 10 days following date of other sprays.

All trees were sprayed on one day, excepting one group treated ten days later. The checking of results was begun with each group of treated trees at the same time, 17 days after the early treatment, or seven days after the late treatment. The tabulation of results was completed in five days before any larvae of the overwintering brood in this locality were seen to have pupated. To determine the results, typical trees or shoots were cut down and transferred to the laboratory where each leaf bud and blossom was dissected, counted, and the numbers of larvae present recorded.

The results of the experiment are summarized in table 1. The percentage of control was computed according to the formula:

$$100-\left(100\times\frac{\text{PERCENTAGE OF INFESTATION IN TREATED PLOT}}{\text{PERCENTAGE OF INFESTATION IN UNTREATED PLOT}}\right)=\text{PERCENTAGE OF CONTROL}$$

The data indicate that basic lead arsenate is effective in reducing the

Table 2.—Summer control experiments, 1932.

Experiment No.	Variety	Plot No.	Material and Concentration, (per 100 Gals. for Spray; per 100 Lbs. for Dust)*	Application: Date	Application: Method	Application: Amt. used Gals. per Tree for Spray; Lbs. per Acre for Dust	Trees Counted	Date of Harvest	Results: Total Peaches Counted	Results: Mean Per cent Infested	Results: Per cent Control
		1	Basic lead arsenate, 3 lbs.	June 1	spray	4.2	6	Aug. 5–6	2821	1.4	44
		2	Basic lead arsenate, 3 lbs.**	June 3	spray	2.5	6	Aug. 5–6	2672	1.5	40
		3	Natural cryolite, 3 lbs.	June 2	spray	4	6	Aug. 5–6	2745	1.8	28
	Mid-summer (Hauss)	4	Natural cryolite, 3 lbs.	June 2	spray	4					
			Basic lead arsenate, 3 lbs.	July 12	spray	7.3	4	Aug. 5–6	1134	1.8	28
		5	Basic lead arsenate, 3 lbs.	June 1	spray	4.2					
			Oil and nicotine sulphate, 2 gals. and ¾ pint†	July 15	spray	7	6	Aug. 5–6	3723	1	00
		6	Check, no treatment				6	Aug. 5–6	3474	2.5	
		1	Basic lead arsenate, 3 lbs.	June 1	spray	4.2					
			Basic lead arsenate, 3 lbs.	July 12	spray	4.8	6	Sept. 15	1814	1.4	56
		2	Natural cryolite, 3 lbs.	June 2	spray	3					
II	Phillips		Natural cryolite, 3 lbs.	July 15	spray	4	6	Sept. 15	1840	1.7	47
		3	Basic lead arsenate, 30 lbs. and sulfur 70 lbs.	June 5	dust	48	6	Sept. 15	1539	2.2	31
		4	Basic lead arsenate, 30 lbs. and sulfur 70 lbs.	June 5	dust	48					
			Basic lead arsenate, 30 lbs. and sulfur 70 lbs.	July 15	dust	50	6	Sept. 15	1835	2	37
		5	Check, no treatment				6	Sept. 15	2241	3.2	
		1	Basic lead arsenate, 3 lbs.	June 7	spray	7.3	4	Aug. 9	2390	.7	67
		2	Basic lead arsenate, 3 lbs.	June 7	spray	7.3					
			Basic lead arsenate, 3 lbs.	July 16	spray	6.3	4	Aug. 9	2448	.7	67
III	Mid-summer	3	Basic lead arsenate, 3 lbs.	June 7	spray	7.3					
			Basic lead arsenate, 3 lbs.	July 16	spray	6.3	4	Aug. 9	2764	1.3	38
			Basic lead arsenate, 3 lbs.	Aug. 4	spray	5					
		4	Check, no treatment				4	Aug. 9	3158	2.1	
		1	Basic lead arsenate, 3 lbs.	June 6	spray	6.7					
		2	Basic lead arsenate, 3 lbs.	June 6	spray	6.7	6	Sept. 1	2268	3.2	69
			Basic lead arsenate, 3 lbs.	July 16	spray	4.5	6	Sept. 1	2537	2.1	80
		3	Basic lead arsenate, 3 lbs.	June 6	spray	6.7					
			Basic lead arsenate, 3 lbs.	July 16	spray	4.5	6	Sept. 1	3010	1.8	83
IV	Phillips		Basic lead arsenate, 3 lbs.	Aug. 11	spray	4.8					
		4	Basic lead arsenate, 3 lbs.	July 6	spray	6.7					
			Basic lead arsenate, 3 lbs.	July 16	spray	4.5					
			Basic lead arsenate, 3 lbs.	Aug. 11	spray	4.8	6	Sept. 1	2125	3.2	69
			Basic lead arsenate, 3 lbs.	Aug. 23	spray	4.3					
		5	Check, no treatment								
			Additional check trees††				8	Sept. 1	1323	10.3	
							2	Sept. 4	737	8.3	

* A conventional calcium caseinate spreader was used with all sprays involving basic lead arsenate; ¾ gallon of paste oil emulsion to 100 gallons of spray was used with cryolite.

** Commercial application made by operator of orchard.

† A light-medium grade of a paste type of oil emulsion and nicotine sulphate, (40%).

†† Trees from periphery of check plot bearing heavier and more nearly normal crop than check trees counted first.

numbers of the overwintering larvae, when applied during the period in the spring when the majority of that brood is feeding.

Summer Control Experiments, 1932

Other control experiments were conducted in 1932 to show the effect of the use of toxic materials against the later broods of larvae. Often in commercial practice, as mentioned previously, toxic agents, usually basic lead arsenate, are used in efforts to reduce the summer populations. Both sprays and dusts have been used during May or June and occasionally later. The use of arsenicals on any variety of peaches later than within sixty days of harvest, however, has been discouraged by canners because of an apprehension of residual poison.

In two of the four experiements to be described, fruit from the test plots was withheld from market in accord with crop curtailment plans, facilitating a trial of the late sprays on a commercial scale.

The results of these experiments are presented in table 2. Each of the test plots consisted of at least 16 trees, were square or rectangular, and with one exception the trees checked for results were located at or near their centers. All the orchards used in the tests received, in addition to the experimental treatments, a spring spray of basic lead arsenate directed against the overwintering larvae. This application, mandatory in the region, was made by the operators of the orchards before the sites of experimentation were chosen.

The times at which test applications of spray or dust were made included early June when larvae of the first summer generation were feeding, July when most of the larvae present were of the second summer generation, and at two periods in August during which month larvae of the second and third summer generations were predominant. In only one plot, it may be noted, were treatments made at all these four periods, and that necessarily on the Phillips variety, the latest to ripen. Other tests involved various numbers of applications.

The dates of application were determined by observations of the development of the borers in each orchard, and an effort was made to complete each treatment just previous to the appearance of the greatest number of larvae of the generation or generations thought to be currently present. An exception was the second August spray which was used a short time before harvest as a cover to protect the ripening fruit. At this time the generations could be seen to be overlapping.[2]

A determination of the degree of infestation in each plot after treatment was made by examining all the fruit picked from the trees selected for counting, and the fallen fruit present beneath those trees. Fruits bearing larval injury were considered "infested." The counting was done when an orchard was harvested by its operator, or in the unharvested orchards when fruit reached a condition suitable for marketing.

The percentage of control, or the percentage of reduction in infesta-

[2] The correlation between dates of the treatments and the seasonal life history of the twig borer may be observed by reference to an earlier paper: **Jones, L. S.** 1935. Observations of the habits and seasonal life history of *Anarsia lineatella* in California. Jour. Econ. Ent. **28**(6): 1002–11. Dec.

tion attributable to each treatment, was calculated according to the formula previously mentioned.

Plot experiment I.—This experiment was planned to show the effects of one and two late applications of toxic materials on a midsummer variety, in this test the Hauss type. The percentage of infestation in the check plot was too small to warrant definite conclusions. The 2.5 per cent of infestation in this plot, untreated except for the spring spray, represents satisfactory commercial control. The basic lead arsenate appeared slightly more effective than natural cryolite in causing further reductions in populations; applications of the latter in June and July accomplished no more than the one in June. The oil and nicotine sulfate combination as a late spray merits additional work as do any materials leaving no deleterious residue.

Plot experiment II.—This test, performed on Phillips peaches in the same orchard used for experiment I, revealed a slightly higher percentage of infestation in the check plot. Two dustings with basic lead arsenate and sulfur were not significantly better than one application. The dust was apparently less efficient than sprays of either basic lead arsenate or cryolite. The deposit of poisonous material after dusting, even under best conditions, appears slight in comparison with that left by sprays.

Plot experiment III.—In this experiment, one, two and three applications of basic lead arsenate were made in an orchard of early midsummer peaches. It is evident that the application in June was probably responsible for any reduction in infestation which was accomplished by the summer treatments. The occurrence of an infestation in the triple-sprayed plot larger than that observed where one and two applications were made was no doubt caused by a lack of homogeneity in infestation in the area selected for experimentation.

Plot experiment IV.—Through this test was demonstrated the efficacy of one to four summer applications of basic lead arsenate on Phillips peaches. The 10.3 percentage of infestation in the check plot was distinctly higher than a maximum of 3.2 per cent noted in treated plots. The degree of control secured by one June spray was not significantly raised by as many as three subsequent applications. It may be observed in table 2 that the check trees counted first bore a lighter crop than the treated trees; this was because of inefficient thinning at the start of the season. However, two trees at the periphery of the check plot which did have a normal crop showed 8.3 per cent of the fruit to be infested.

RESULTS OF CONTROL EXPERIMENTS

The spring spray of basic lead arsenate appeared to reduce effectively the overwintering population of larvae. The tests of later treatments, undertaken because of the possibility that increases in summer populations should be checked, gave less positive results. It is evident that the most effective summer treatment was the June spray of basic lead arsenate against the first summer brood of larvae. The value of late sprays during years when large populations of borers are present cannot be predicted on the basis of work done.

ORANGE WORMS IN CALIFORNIA AND THEIR CONTROL[1]

A. J. BASINGER and A. M. BOYCE, *Citrus Experiment Station, Riverside, California*

The colloquialism "orange worms" refers collectively to the larvae of three species of Lepidoptera that cause damage to citrus in California. These insects are, in the order of importance, the orange tortrix *Argyrotaenia* (*Tortrix*) *citrana* (Fern.),[2] *Holcocera iceryaeella* Riley, and *Platynota stultana* Wals. Oranges and grapefruit, primarily, are affected. Injury occurs as a result of the larvae feeding on the fruit. Typically, the injury may be a hole extending through the peel or rind into the fleshy portions of the fruit, or it may be only superficial and extend partially through the peel. Affected fruits either drop before picking time or are graded out in the packing-house as culls.

The first record of orange worm damage in California was reported by Coquillett[3] in 1885, who forwarded specimens to the United States Department of Agriculture at Washington, where the species was found to be undescribed. In 1889 Fernald[4] described it as *Tortrix citrana*. Since that time it has been the most important orange worm in southern California. Later it was found that *Holcocera iceryaeella*, which is rather generally present throughout the coastal citrus areas, causes damage principally to Valencia oranges. *Platynota stultana* has not been found infesting oranges in sufficient abundance to be economically important.

The history of the orange worms indicates that serious injury has apparently occurred periodically every five to seven years. This is more pronounced in the localities where the damage is due almost entirely to the orange tortrix. This species is often very highly parasitized and is also adversely affected by high temperatures, both of which factors contribute to periodicity. *Holcocera iceryaeella*, on the other hand, maintains a more uniform population year after year, since it is not highly parasitized and occurs mainly in the coastal areas where the climate is rather uniform. In the coastal areas, however, infestations of orange worms consist mainly of mixed populations of the orange tortrix and *Holcocera iceryaeella*.

The extent of injury caused by orange worms may range from a negligible amount to 40 per cent or more of the crop. Losses of 10 to 15 per cent of the crop are common. During the epidemic condition of these insects in the 1933–34 season, it is conservatively estimated that the value of the fruit destroyed by orange worms in southern California exceeded $100,000.

The study of orange worm control was undertaken in 1924 by the

[1] Paper No. 332, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, Calif.

[2] Data in this paper refer mainly to this species.

[3] **Coquillet, D. W.** 1894. Report on some of the injurious insects of California. The orange leaf roller *Tortrix citrana* Fern. U. S. D. A. Bur. Ent. Bul. 32:24.

[4] **Fernald, C. H.** 1889. North American Microlepidoptera, *Tortrix citrana* n. sp. Ent. Am. 5(1):18.

senior author. At first, efforts were directed toward determining the possibility of obtaining control of the orange tortrix particularly by the use of insect enemies. Although there are several insects parasitic on this species, some of which are very important, it was not found possible to utilize them in a practical way. Attention was therefore directed toward other control measures.

Among the earlier attempts at control was the destruction of the fallen fruit; but this was not effective since the main portion of the population of larvae remained on the tree. Only a few larvae dropped from the tree with the fruit. Experiments with arsenicals were unsuccessful because the arsenic adversely affected the quality of the fruit. Fumigation with hydrocyanic acid gas even at dosages greater than the trees could tolerate, was not effective. Likewise, neither the regularly used mineral oil nor lime sulfur sprays for the control of scale insects and mites were effective.

In 1925, experiments were conducted with sodium fluosilicate. This material proved to be very toxic to orange tortrix larvae, but it caused severe injury to the foliage and fruit. The control work was temporarily discontinued at that time since the populations of orange worms were at a very low ebb and economic injury did not occur. Later, in 1930, studies were resumed.

Extensive tree-tolerance tests, with various fluorine compounds applied as sprays and dusts, were conducted in the coastal area of Orange county. These tests extended throughout the year in order to observe the effect of the several materials upon the foliage and fruit at different seasons and under different weather conditions. The following materials were used in these and other tests: ammonium fluoride, ammonium fluosilicate, sodium fluoride, sodium fluosilicate (material from five different manufacturers), sodium fluoaluminate (cryolite, both natural and synthetic), magnesium fluoride, magnesium fluosilicate, potassium fluoride, potassium fluosilicate, potassium fluoaluminate, calcium fluoride, calcium fluosilicate "compound," iron fluoride, nickel fluoride, zinc fluoride, barium fluoride, barium fluosilicate, and lead fluoride.

Light-pressed herring oil and highly refined light-medium grade mineral oil[5] were used as ahesives in both the sprays and dusts. In the dust tests talc (fiber), sulfur, and several types of clays were each used as diluents for the fluorine compound.

The results of these tree-tolerance tests showed that of the more readily available fluorine compounds for insecticide use a few may be safely applied on citrus; namely, sodium fluoaluminate (cryolite), potassium fluoaluminate, and barium fluosilicate. The more soluble compounds caused severe plant injury characterized by various degrees of leaf burn and premature abscission as well as severe burning of large areas in the peel of the fruit. In certain instances with some of the less soluble materials, small pits developed in the peel of the fruit, and in others there was an excessive drop of leaves and fruit without evidence of external

[5] Highly refined, light-medium grade mineral oil as used in this paper refers to an oil of the following specifications: unsulfonatable residue 90 per cent; distillation range—10 per cent at 587° F, 50 per cent at 632° F, 90 per cent at 702° F.

injury. These and other studies showed that the use of an adhesive agent with the commonly used fluorine insecticides was essential to prevent excessive and rapid weathering.

During the time of these experiments and afterwards there were insufficient numbers of orange worms present to warrant further work in the field or laboratory. However, in 1933 the populations increased and the work was continued.

Laboratory toxicity tests were conducted with cryolite (synthetic) and barium fluosilicate applied as dusts, using larvae of the orange tortrix. Two series of tests with five replications of each were made. In one series each material was applied undiluted, and in the other series each was thoroughly mixed with talc and a light-medium mineral oil in the following proportion by weight: fluorine compound 30 per cent, talc (fiber)

Table 1.—Results of experiments to control orange worm on Valencia oranges, Downey, Calif., 1933–34.

Date (1933)	Treatment	Average Number of Worm-damaged Fruits Lost per Tree from Time of Treatment to Harvest, Oct. 12, 1933–July 9, 1934[6]
Oct. 12	Spray—Cryolite (synthetic) 3 lbs. to 100 gals. with 1½ per cent light-medium oil emulsion for citrus red mite and orange worm control. 25 gals. per tree.	101[7]
Oct. 18	Dust—Cryolite (synthetic) 30 per cent; talc. 65 per cent; oil[8] 5 per cent. 2 lbs. per tree.[9]	158[7]
Oct. 18	Dust—Cryolite (synthetic) 30 per cent; diatomaceous earth 65 per cent; oil[8] 5 per cent. 2 lbs. per tree.[9]	244[7]
	Check—no treatment for orange worms.	522

65 per cent, oil 5 per cent. The material was discharged by air pressure into a bell jar where it settled uniformly over the fruit hanging within. Ten treated oranges, which formed the unit for each test, were placed in a battery jar and one larva was placed on each orange. Data were taken when each test had been in progress for 192 hours. The results, expressed in the percentage of larvae alive at the end of the experiment, follow: cryolite, undiluted, 2 per cent alive; barium fluosilicate, undiluted, 6 per cent alive; and check (no treatment) 88 per cent alive. In the series where the fluorine compound was mixed with talc and oil the results were: barium fluosilicate, 2 per cent alive; cryolite, 6 per cent alive; check (talc), 80 per cent alive; and check (no treatment) 94 per cent alive. The average number of damaged oranges in the tests where the fluorine compounds were used amounted to 4 per cent while the average in the check series was 63 per cent. These limited experiments demonstrated that both cryolite and barium fluosilicate were valuable, not only in killing the larvae but in protecting the fruit from larval feeding before mortality occurred.

[6] Data were obtained from five key trees in each plot.

[7] These data do not represent the actual effectiveness of the treatment owing to the fact that damage had been occurring for some time prior to treatment. Therefore a portion of the oranges that dropped and were necessarily included in these data were injured before the insecticide was applied.

[8] Light-medium mineral oil.

[9] Dust mixture applied several days after oil spray for citrus red mite control.

The first successful application of a fluorine compound in the field for the control of orange worms was made in October 1933, on a Valencia orange grove at Downey, consisting of 480 large trees. In this case synthetic cryolite was used in a combination spray treatment for orange worms and for the citrus red mite *Paratetranychus citri* McG. Dust applications solely for orange worms were also made, comparing talc and diatomaceous earth as diluents. The data are presented in table 1.

Each of the treatments was effective enough to offset the cost involved. However, the spray application of cryolite was most effective and apparently prevented a loss of as much as 400 fruits per tree. In the dust treatments, talc as a diluent was evidently more satisfactory than diatomaceous earth.

Cryolite, both natural and synthetic, and barium fluosilicate were applied as sprays on June 1, 1934, in a grove of Valencia oranges at Irvine. Each plot consisted of 40 trees and data were taken from all of

Table 2.—Results of experiments to control orange worms on Valencia oranges, Irvine, Calif. 1934.

Treatment June 1, 1934	Average Number of Worm-Damaged Fruits Lost per Tree from Time of Treatment to Harvest. (June 1 to Sept. 24, 1934)
Cryolite (natural) 3 lbs. per 100 gallons[10]	20
Cryolite (synthetic) 3 lbs. per 100 gallons[10]	21
Cryolite (synthetic) 1½ lbs.per 100 gallons[10]	21
Barium fluosilicate 3 lbs. per 100 gallons[10]	22
Check: no treatment	77

the trees in the plots. Heavy losses of fruit had already occurred, since the infestation of orange tortrix had been present for about 10 months prior to treatment. The fruit that remained on the trees was not to be harvested for another four months. The data obtained from this experiment are presented in table 2.

There was a saving of approximately 55 oranges per tree resulting from the treatment, even though it was applied too late for maximum protection. It is of importance to note that a dosage of 1½ pounds of cryolite (synthetic) per 100 gallons afforded as effective results as did 3 pounds.

During June 1934, in the Corona, La Verne and other districts, young larvae, principally orange tortrix, were present under the sepals or "buttons" of a large percentage of the small green oranges. The feeding of the larvae at this stage and location caused scars which in some cases resembled injury caused by the citrus thrips, *Scirtothrips citri* (Moult). Detailed studies later showed that this scarring did not seriously affect the size or grade of the fruit. Throughout the late summer and early fall the larvae were relatively inactive and developed slowly. They moved from the buttons of the young fruit and either occupied shelters previously made by larvae or old curled leaves; in many cases new shelters were made of old petals and flowers that had fallen and lodged among the foliage of the tree. However, this same brood of larvae when much larger, during November and December, and later, caused serious damage to the crop by eating holes in the then nearly mature fruit.

[10] Liquid blood albumin adhesive spreader used at the rate of ¼ pint per 100 gallons.

A large series of spray and dust applications of fluorine and other compounds was made in an extensive Washington navel orange planting at Corona in June 1934, while young larvae were present under the buttons. Before treatment the degree of infestation was determined by taking a random sample of small fruits, usually four fruits from each of 12

Table 3.—Results of experiments to control orange worms on Washington navel oranges, Corona, Calif. 1934.

Date (1934)	Material and Concentration	Per Cent of Fruits with Live Larvae under Buttons Prior to Treatment	Number of Recently Damaged Fruits Observed per Hour Approximately 130 Days After Treatment
June 26	Pyrethrum 5% 1–800	11.5	70
June 26	Rotenone 5% 1–800	31.2	69
June 26	Contact #1 1–800[11]	25.	77
June 26	Pyrethrum 5% 1–800, Cryolite (synthetic)[12]	16.	1
June 26	Rotenone 5% 1–800, Cryolite (synthetic)[12]	14.8	2
June 26	Contact #1 1–800, Cryolite (synthetic)[12]	14.2	2
	Check: no treatment	30.3	116
July 2	Nicotine-bentonite, 5 lbs. to 100 gals.	36.5	63
July 2	Barium fluosilicate	8.9	4
July 2	Potassium fluoaluminate	28.5	0
July 2	Cryolite (synthetic)	33.9	1
July 3	Cryolite (natural)	25.	1
July 3	Cryolite (natural-special)[13]	12.5	3
July 2	Cryolite (synthetic) 50%; talc 50%. Dust 1 lb. per tree.	32.	6
July 2	Cryolite (synthetic) 50%; talc 45%; oil[14] 5%. Dust 1 lb. per tree.	24.	0
July 2	Cryolite (synthetic) 100%. Dust ½ lb. per tree	31.	12
July 2	Cryolite (synthetic) 100%. Dust 1 lb. per tree.	29.	3
July 2	Cryolite (natural) 50%; talc 50%. Dust 1 lb. per tree.	30.	5
July 2	Barium fluosilicate 50%; talc 50%. Dust 1 lb. per tree.	41.	6
	Check; no treatment	17.3	175

Note—All fluorine compounds in sprays used at 3 lbs. to 100 gals. One-half pint liquid blood albumin spreader to 100 gals. used in all sprays.

trees in each plot. The fruits were examined with the aid of a low-power binocular microscope in the laboratory and the number of fruits with live larvae present was recorded. Examinations were again made at an appropriate time after treatment, to note the effectiveness of the materials in causing mortality of the larvae. With the exception of scarring of the small fruits, there was no injury apparent until about the first of November, when the larvae began to feed on the large fruits. Shortly

[11] A proprietory aliphatic thiocyanate compound now known as *Loro*.
[12] Compare with efficacy of cryolite (synthetic) alone applied as spray as shown below.
[13] An experimental lot of specially prepared material that possessed a positive electric charge.
[14] Light-medium mineral oil.

afterward, further data on the effect of the control experiments were taken. The damaged fruits observed on the tree per man per hour were counted and the number recorded. Certain of the results obtained from these experiments are presented in table 3.

In connection with the experiments presented in table 3, data which are not included showed that an application of any one of the several fluorine compounds resulted in a high mortality of the small larvae that were present under the buttons of the fruit. Further indications of this fact are evident from the data in table 3, where the percentage of fruits with live larvae present in June are compared with the number of re-

Table 4.—Results of experiments to control orange worms, using fluorine compounds with the so-called emulsive oils as commonly used for the control of scale insects, Washington navel oranges, Azusa—La Verne, Calif., 1934.

Treatment			Results of Examination	
Date (1934)	Oil[15]	Fluorine Compound[16]	Per cent of Fruits with Live Larvae Under Buttons Prior to Treatment	Number of Worm-damaged Fruits Observed per Hour Approximately 90 Days After Treatment
Grove I				
Aug. 13		Cryolite (synthetic)	17.3	4[17]
Aug. 17	Brand	Cryolite (natural)	11.1	6[17]
Aug. 15	A	Barium fluosilicate	9.6	26[17]
Aug. 17		None (Check)	13.5	256[17]
Grove II		Cryolite (synthetic)	8.3	6
Aug. 31	Brand	Barium fluosilicate	14.5	6
	B	None (Check)	5.7	123
Grove III	Brand	Cryolite (synthetic)	19.2	0
Aug. 28	C	None (Check)	17.3	74

cently damaged fruits in November. It is of particular interest to note that the fluorine compounds applied as dusts during early summer were very effective. On the basis of these tests the most promising dust mixture is one composed of 50 per cent fluorine compound, 45 per cent talc (fiber), and 5 per cent light-medium mineral oil. The oil evidently is important in increasing adhesiveness. The organic compounds, that is, pyrethrum, rotenone, nicotine, and *Contact No. 1* (now known as *Loro*), as used in these tests gave unsatisfactory results.

In the Azusa-La Verne districts, during August 1934, orange worm control experiments were conducted in several groves wherein cryolite and barium fluosilicate each was incorporated in the regular oil spray treatment for the control of scale insects. Several brands of the so-called "emulsive oils"[18] were used. Previous laboratory and field work[19] had

[15] Light medium emulsive oil used at 1¼ per cent concentration.

[16] Used at 3 pounds per 100 gallons of spray mixture.

[17] Number of worm-damaged fruits on the ground under 12 trees. The data are not based on time in these instances.

[18] "Emulsive oil" as used in this paper refers to a spray oil preparation that contains about 98 per cent mineral oil to which has been added about 2 per cent of an oil soluble compound which causes the oil to emulsify when agitated with a small amount of water in the field spray equipment. This term is intended to include all commercial brands of such oils as used in citrus spraying in California that are locally referred to as "soluble oils" or "emulsible oils."

[19] Persing, C. O., A. M. Boyce and C. Snow. Unpublished data on file at the University of California Citrus Experiment Station, Riverside, California.

shown that where the fluorine compound was wetted with certain of these specially treated oils before emulsification in the spray tank, it was applied to the tree in the oil phase of the spray mixture. Through this procedure a large portion of the fluorine compound in the spray mixture is deposited on the tree. It had previously been determined that under ordinary conditions the incorporation of cryolite or barium fluosilicate in the regularly used oil sprays did not adversely affect the action of the oil in scale insect control. The results of these experiments are presented in table 4.

Table 5.—Results of experiments to control orange worms with combination dust treatments for the control of citrus thrips and for correction of the mottle-leaf disease. Washington navel oranges, Corona, Calif., 1935.

Plot No.	Material and Concentration	Date (1935)	Per Cent of Fruits With Live Larvae[20] After Treatment, June 21, 1935
E 18	Cryolite 40%,[21] sulfur 60%[22]; $1\frac{1}{4}$ lbs. per tree	May 7	0
W 18		May 7	0
E 25		May 7	0
30		June 19	2.1[23]
27	Cryolite 38.5%, sulfur 58.5%, oil 3%[24]; $1\frac{1}{4}$ lbs. per tree	May 25	0
28	Cryolite 37.5%, sulfur 57.5%, oil 5%; $1\frac{1}{4}$ lbs. per tree	May 25	0
32	Cryolite 37.5%, sulfur 57.5%, dry blood albumin 5%; $1\frac{1}{4}$ lbs. per tree	June 19	2.1[23]
34	Cryolite 35.8%, sulfur 53.8%, zinc oxide 10.4%; $1\frac{1}{4}$ lbs. per tree	June 19	1[23]
W 15[25]	Sulfur $\frac{3}{4}$ lb. per tree	April 26	32
E 27		April 26	10
W 27		April 26	14
W 26		May 4	19
W 25[26]		May 7	20
29		May 25	22
E 26	Check, no treatment		15
20			44

Excellent control of orange worms was obtained in these experiments. The plots in grove I were each five acres in extent, and further observations were made when the crop was harvested. In the three plots where a fluorine compound was used, the loss resulting from orange worm injury was practically negligible, but in the check plot injury was severe.

Further control experiments were conducted in the Corona district in the spring of 1935 with combinations of cryolite (synthetic) with sulfur for citrus thrips control. In some instances certain zinc compounds were included in the dust mixture for correction of the mottle-leaf disease. The dust mixtures were prepared and applied so that each tree would receive approximately one half pound of cryolite. The results obtained from these experiments to date are presented in table 5.

[20] Small larvae under the buttons.
[21] Synthetic cryolite was used in all instances.
[22] Sulfur fineness 95% through 325-mesh per inch (U. S. Bureau of Standards sieve series) in all instances.
[23] Data taken July 12, 1935.
[24] Light-medium mineral oil used in all instances.
[25] This plot was dusted with *Dutox* (80% $BaSiF_6$) 50%+talc 50%, in June 1934.
[26] This plot was sprayed with cryolite, 3 lbs. to 100 gals. water, in January 1935, but repeated rains dissipated the fluorine and control of the spring brood of larvae was unsatisfactory.

The data show that satisfactory control of young orange tortrix larvae that are under the buttons of the small oranges may be obtained when cryolite is included in the dust mixture used for citrus thrips and mottle-leaf control. It was not possible to conduct similar experiments with barium fluosilicate; however, it is very probable that comparable results would have been obtained.

Fairly extensive experimental treatments, data from which will not be reported here, have shown that best results have been obtained when the fluorine compound was applied during the summer months or dry season. On Washington navel oranges, one treatment applied during June, July and August 1934 afforded very satisfactory results throughout the crop season. At this same period one treatment on Valencia oranges afforded effective control until June 1935, at which time young worms began to appear in important numbers under the buttons of the new fruit.

Summary

The orange worm problem has existed in California for many years, though serious economic losses apparently occur periodically in cycles of about five or seven years. Damage is caused principally by the larvae of *Argyrotaenia* (*Tortrix*) *citrana* (Fernald), though *Holcocera iceryaeella* Riley and *Platynota stultana* Wlsm. are also involved. Experimentally, satisfactory control of these orange worms has been obtained in both the laboratory and in the field through the use of cryolite, both the natural and synthetic product, and barium fluosilicate applied as dusts and sprays. Present indications are that cryolite and barium fluosilicate may be combined with certain of the regularly used oil-spray mixtures for scale insect and citrus red mite control, with nicotine and derris compounds (barium fluosilicate with nicotine sulfate excepted) for citrus aphid control, with sulfur dust for citrus thrips control, and with zinc oxide for correction of the mottle-leaf disease of citrus. None of the organic compounds as used were effective.

The Shipping of Oregon huckleberry, evergreen smilax, and galax is no longer considered to constitute a risk in dissemination of the gypsy moth, and these plants were therefore included in a list of plants which the Bureau of Entomology and Plant Quarantine consider exempt from the federal quarantine restrictions. The list is designated Circular BEPQ-386, dated November 26, 1935. American bittersweet and evergreen cones are on the other hand, now subject to the inspection requirements.

Owing to the discovery of the peach mosaic disease in parts of Riverside and San Bernardino counties, California, and of reinfestations of the white snail in the city of San Diego, the Director of Agriculture on February 29 placed quarantine regulations relating to the movement of the host plants and the host products from the infested areas to other parts of California.

EASTERN BRANCH

PAPER-READING SESSION, SEVENTH ANNUAL MEETING

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BARK BEETLES AND OTHER POSSIBLE INSECT VECTORS OF THE DUTCH ELM DISEASE *CERATOSTOMELLA ULMI* (SCHWARZ) BUISMAN

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Introduction.—The Bureau of Entomology and Plant Quarantine, through its Division of Forest Insect Investigations, has conducted research on the insect vectors of the Dutch elm disease fungus since August 1933. The work began soon after the discovery of the disease in New Jersey. During this period the work has been carried on in close cooperation with the Division of Forest Pathology of the Bureau of Plant Industry, U. S. Department of Agriculture.[1] It is the aim of the projects, as conducted by the Bureau of Entomology and Plant Quarantine, the Bureau of Plant Industry, and the states affected, to eradicate the disease from the United States. Insects, especially two species of bark beetles, are found associated with the spread of the disease in this country, and important information on them has been accumulated in the course of laboratory and field experiments. Since such information is pertinent to the success of the large undertaking, it is thought advisable to present the available data on insect vectors at this time. For the sake of brevity, several interesting details on biology, transmission experiments, and field observations are omitted, but it is anticipated that the subject matter can be treated more fully in a later publication.

Biology of *Scolytus multistriatus* Marsham.—The smaller European elm bark beetle, which is widely distributed in Europe, was first found in this country in Massachusetts by J. W. Chapman (*1*) in 1909. J. N. Knull (*2*), after a preliminary survey late in 1933, recorded this species from eastern Massachusetts, western Connecticut, southeastern New York, the northern half of New Jersey, and southeastern Pennsylvania.

The writers have taken this species in southeastern New Hampshire, northern Delaware, and in many additional localities in the areas mentioned above.

S. multistriatus confines its attack to elms. Shortly after emergence, both males and females often feed on the twigs of healthy elms, especially in the crotches. Severe feeding scars measure 5 mm. in length, 2 mm. in

[1] The writers are indebted to Dr. F. C. Craighead, William Middleton and L. H. Worthley of the Bureau of Entomology and Plant Quarantine for many helpful suggestions in the course of the investigations; also to T. H. Jones, D. E. Parker, and other members of the staff at the bureau's Morristown, N. J., laboratory, especially to Dr. F. M. Wadley, who worked on the biology of the bark beetles until March 15, 1935; to Dr. Curtis May of the Dutch elm disease laboratory, Bureau of Plant Industry, Morristown, N.J., for suggestions and effective cooperation; to Dr. J. M. Walter, and especially to C. S. Moses, who devoted a large portion of his time in 1935 to culturing samples of insects, insect galleries, and trees submitted; also to several other members of the same bureau laboratory for suggestions and assistance in various ways.

width, and 1 mm. in depth. The beetles have also been observed to make egg tunnels in the trunks of healthy elm trees less than 2 inches in diameter as well as at the base of small branches in the crown. Although the beetles may make small egg tunnels in living bark and wood, development of the brood is soon arrested. For breeding purposes, they prefer recently cut or weakened and dying branches or trunks, and seldom attack branches less than an inch in diameter. These habits of feeding and boring enable the beetle to function successfully as a vector of the Dutch elm disease fungus.

The entrance tunnel, which the adult female makes directly through the bark, is readily recognized by the accumulation of very fine, reddish borings about the exterior of the tunnel. Shortly after the egg gallery is started, the female backs to the entrance opening at frequent intervals and voids several pellets. The male follows the female so closely in and out of this tunnel that her excreta become lodged in the hairs on the front of the male. Thus it appears that the male indirectly aids the female during these activities in clearing the gallery. Whenever the female remains for some time at the gallery entrance, the butting activities of the male become accelerated, and the penis is rapidly extended and withdrawn. Suddenly the male reverses his position and copulates with the female. They immediately re-enter the gallery entrance, the male entering backwards, where coition is presumably consummated.

The egg tunnel, which follows the grain of the wood, is usually straight. Eggs are deposited in niches closely spaced along both sides of the tunnel. The freshly deposited eggs are white, somewhat shiny, and almost spherical, about .36 mm. by .30 mm. in size.

Most of the larval galleries begin at right angles to the egg gallery, and become more tortuous as the larvae increase in size. The mean number of larval tunnels extending from 63 egg tunnels was found to be 73.3. Measurements of 53 larval tunnels terminating in pupal cells gave an average length of 43 mm. (minimum 15 mm., maximum 63 mm.). As pointed out by Chapman (*1*), the galleries tend to be rather short and deep in sound bark and wood, whereas they vary greatly in size in decaying bark and wood. Intermingled with the packed borings in the tunnels are the larval casts, which, according to Readio (*3*), are probably five in number.

Each pupal chamber is a continuation of the larval tunnel but often at right angles to it. Within these cells, the first brood of the insect, during May, spend two days in the prepupal stage and 10 days or longer in the pupal stage. When the beetles emerge they cut their way to the surface of the bark and leave characteristic circular emergence holes.

Wadley (unpublished laboratory notes, 1934) observed *S. multistriatus* to be inert at 45° F, to crawl at 52°, to fly at 70°, and to be vigorously active at 85 to 90°. He also recorded that the length of the life cycle, from emergence of parents to emergence of their adult progeny, ranged from 45 to 60 days in summer in an outdoor insectary, and appeared to be from 55 to 60 days in field locations. The egg stage requires about five days in summer and the larval development about 23 to 30 days. Indications are that this species has two full generations and a partial third in

northern New Jersey and vicinity. All stages of *S. multistriatus* may be found from the latter part of May until the middle of October. Moreover, late in September in northern New Jersey, several brood galleries were noted to contain all stages of this beetle. Where adults bored into bark and wood late in July, their oldest progeny became adults in September, while the younger larvae went into hibernation. Adults that infested bark and wood in August produced full-grown larvae before development was arrested in the fall; the progeny of those that entered bark and wood during September 1934 hibernated as immature larvae which gave adults during July and August 1935.

Preliminary laboratory experiments have revealed that some of the larvae can withstand two months submergence in tap water and, upon being removed, are able to complete their development.

Wadley (unpublished laboratory notes, winter 1933–34) found that the maximum emergence from overwintered bark collected in the field was slightly over 100 adults for each square foot of bark, or four per egg gallery. The most favorable wood in outdoor rearing cages yielded about 400 adults per square foot; the most favorable single stick between 600 and 700. In the most successful cage the increase of adult progeny over parents was nearly twenty-fold. Larval populations of 200 and 400 per square foot in infested portions of bark seem to be fairly common in the field.

Scolytus multistriatus adults occasionally attack living or freshly cut wood, but usually abandon the attack on account of the presence of sap. Logs stored during the summer at outdoor temperature, but protected from rain, dried rapidly. Logs seasoned as little as three days were suitable for beetle attack, and normal development followed; those a month old were less favorable, while those seasoned for three months were attacked reluctantly by the beetles, with little or no subsequent development.

Biology of *Hylurgopinus rufipes* Eich.—This native elm bark beetle has been recorded by Knull (*2*) from Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, Ohio, Indiana, Kentucky, Missouri and Kansas. In addition to some of these eastern states, our records show that this beetle occurs also in New Hampshire and Rhode Island.

Adults of *H. rufipes* confined with small healthy elm trees in cloth cages fed not only on the twigs, particularly of this season's growth, but also on the trunks. These observations suggest that twig injury may occur under field conditions. The feeding scars of this species are indistinguishable from those made by *S. multistriatus*. The adults bore into the bark of weakened trees, making their egg galleries in the inner bark and outer sapwood.

The egg galleries usually run across or diagonal to the grain of the wood, in contrast to those of *S. multristriatus*, which are more or less parallel to the grain. Usually *Hylurgopinus* galleries have two arms, one of which is longer and more irregular than the other. The brood galleries are chiefly in the inner bark. Evidence was secured this year (1935) indicating that this beetle hibernates in both adult and larval stages in elm

bark, thus confirming Chapman's work of 1911. Approximately 1200 larvae per square foot occurred in one heavily infested log sampled during November 1935. In northern New Jersey there are two generations annually, the first brood emerging in the spring and the second late in the summer and early in the fall. Observations during early winter of 1934–35 indicate that adult *H. rufipes* frequently enter the bark of healthy trees for hibernation—their cells often penetrating the inner bark and occasionally reaching the sapwood. This habit may be significant in the transmission of the Dutch elm disease fungus.

Transmission experiments.—It is generally believed that insects are largely responsible for the spread of the Dutch elm disease fungus in Europe as well as in America. This conclusion has been reached because certain insects have been observed to be associated with diseased trees. In Europe the large elm bark beetle *Scolytus scolytus* Fab. is considered the most important vector, while its smaller relative *S. multistriatus* is a close second. *S. scolytus* does not seem to have become established in America, but *S. multistriatus* is established, and it is interesting to note that the disease is concentrated in an area where *S. multistriatus* is abundant. The native bark beetle *Hylurgopinus rufipes* Eich. is also present in this area. The distribution of the latter species, however, extends far beyond the area of concentration of the disease in New Jersey, New York and Connecticut and into other adjoining and distant states. The Dutch elm disease has not yet been found in eastern Massachusetts and southern New Hampshire where *S. multistriatus* is distributed, presumably from an early introduction at Boston. The above infested area still remains separate and distinct from the beetle-infested and disease-infected area originating around New York City.

In our investigations of insects in relation to the spread of the Dutch elm disease fungus we have attempted to conduct experiments that apply to practical field problems. Special emphasis has been placed on *Scolytus multistriatus* and *Hylurgopinus rufipes* because their life histories and habits may fit them to be vectors of *Ceratostomella ulmi*. It is possible, of course, that other insects also act as carriers, but to date we have no evidence to indicate that this is true. Transmission experiments have been carried on with adults of the elm leaf beetle *Galerucella xanthomelaena* Schr. and the Japanese beetle *Popillia japonica* Newm., which feed on elm foliage; with the buffalo tree hopper *Ceresa bubalus* Fab., the females of which deposit their eggs in elm twigs; with a cicada, *Tibicen chloromera* Walk., which, in confinement at least, does the same; and with adults of the elm borer *Saperda tridentata* Oliv. and the bark weevils *Magdalis armicollis* Say and *M. barbita* Say, which feed on the leaves and the females of which deposit their eggs in the elm bark. Except for occasional instances, which may be due to experimental error, the results with all except *Scolytus multistriatus* and *Hylurgopinus rufipes* have been negative.

The trees used in the transmission experiments have been largely of the American elm, ranging from two to four years in age and from one and one-half to eight feet in height, purchased from nurseries outside the infected area. The trees were planted in wooden butter tubs or galvanized

iron pails. The soil used came from the nurseries or from other places where there were no elms infected with the disease. Considerable care was taken to select healthy trees from well outside the diseased area in obtaining logs for use in experiments where it was necessary to use wood not infected with *Ceratostomella ulmi*. When infected wood was desired, care was taken to select logs in which there was a complete layer of discolored wood immediately under the bark.

To reduce the possibility of stray insects attacking trees or logs used in the experiments, care has been taken to keep them in greenhouses, cages, insectaries, and compartments in which the space intended for ventilation is covered with cotton cloth or metal netting, and when trees are kept outdoors they are covered with cheesecloth.

When it was desired to rear adults of bark beetles, borers, bark weevils, or other insects from wood infested with their immature stages, the wood was placed in tight metal containers in which one or more holes were drilled in the sides. Glass flasks or bottles were connected with these holes on the outside of the container by means of cylinders of metal netting in such a way that the glass receptacles could be readily detached and the adults, attracted into them through their positive reaction to light, removed. The metal containers used were usually lard cans, garbage pails or ash cans. When it was desired to infest elm wood with any particular species of insect, the adults were placed with logs in containers through the walls of which light could enter. In confining adults on small trees or portions thereof for the purpose of securing feeding injury or oviposition, various types of cages have been used. These have included glass jars; cylinders of celluloid, cotton cloth, or metal netting; and a wooden framework covered with metal netting.

The following instances of recovery of the fungus *Ceratostomella ulmi* have been obtained, based on determinations received from the Division of Forest Pathology, Bureau of Plant Industry:

From 16 of 248 originally healthy small elm trees on which 15,007 *Scolytus multistriatus* beetles that issued from logs infected with the fungus were caged and allowed to feed.

From 14 of 51 similar trees on which adults of *S. multistriatus* fed in a large outdoor cage after they issued from infected logs kept in the cage. Occasional injuries caused by adults of *Saperda tridentata* and *Magdalis* that also issued from the logs were noted on these trees.

From 60 of 297 *S. multistriatus* egg galleries made in 11 previously noninfected logs and from 30 of 374 *Hylurgopinus rufipes* galleries made in 19 logs by adults after they had issued from diseased wood and been placed with the logs.

From 16 of 76 egg galleries made in 16 previously noninfected logs by *S. multistriatus* beetles that emerged from noninfected logs and then fed on diseased trees before they were placed with the logs in which the oviposition galleries were made. The diseased trees had been inoculated previously with a spore suspension of *Ceratostomella ulmi* and had good discoloration in the small twigs when the beetles fed on them. While this work was done in the greenhouse, there is reason to think that it may occur in nature.

From 51 of 165 *S. multistriatus* egg galleries and from two of 231 *H. rufipes* egg galleries made in logs that were not infected or infested at the time they were put out in the field in 1935. The galleries were made by beetles that were attracted to the logs under natural conditions. Many diseased elm trees had been removed from the surrounding country.

From six of 29 *S. multistriatus* adults and from one of 14 *H. rufipes* adults collected while crawling on elm in the field in 1935 in New Jersey areas heavily infected with the disease.

Tests to determine whether insects other than *Scolytus multistriatus* and *Hylurgopinus rufipes* act as carriers of the Dutch elm disease fungus have in general given negative results; although positive-culture results were obtained in occasional instances, these were probably due to experimental error in the transmission studies. The following material has given no *Ceratostomella ulmi:*

Table 1.—Insect occurrence in 50 diseased elm trees.

	Scolytus multistriatus		Hylurgopinus rufipes		Other Insect Occurrence[2]		No[3] Infestation Old or New Trees
	New infest., trees	Old[4] infest., trees	New infest., trees	Old[4] infest., trees	New infest., trees	Old[4] infest., trees	
Within the New Jersey-New York infected area, 26 trees	10	9	1	1	13	1	3
Just outside New Jersey-New York infected area, 12 trees	6	6	1	1	11	1	
Distant trees—Connecticut, Ohio, Virginia, Maryland, and Indiana areas, 12 trees			5	6	12		
Total	16	15	7	8	36	2	3

Twenty-three elm trees on which 124 *Saperda tridentata* adults that emerged from diseased wood had fed.

Fourteen trees on which 124 *Magdalis* adults that emerged from diseased wood had fed.

Two hundred thirty-five *Magdalis* oviposition punctures made in noninfected logs by females that had previously fed on diseased trees.

Forty-seven *Magdalis armicollis* adults and 43 *M. barbita* adults collected while they were crawling on elm in New Jersey areas heavily infected with the disease.

Eighty-two adults of *Galerucella xanthomelaena* that had fed on the foliage of trees infected with the disease.

One hundred thirty-two adults of *Ceresa bubalus* that had fed on the twigs of infected trees. Following oviposition in infected trees, approximately 250 individuals of this tree hopper were isolated on 31 disease-free trees to obtain additional oviposition. Subsequently the latter trees and

[3] This column includes such insects as *Magdalis* spp. and cerambycid and bupestid larvae.
[3] No infestation of any wood borers or bark beetles.
[4] Indications of old infestation of *S. multistriatus, H. rufipes, Magdalis* spp. and cerambycid larvae are based on old galleries found.

185 of the dead tree-hoppers were cultured, but no *Ceratostomella ulmi* was obtained.

Insect occurrence in diseased elms.—During the past season one or more members of the entomological staff of this laboratory have been present to examine a number of the trees confirmed as having the fungus *Ceratostomella ulmi* at the time of their removal. At present we have information on 26 such trees from within the New Jersey—New York infected area; 12 from just outside this area; and 12 from the Connecticut, Ohio, Virginia, Maryland and Indiana areas. At the time these trees were removed they were examined for the following information: Size, site, evidence of bark beetle occurrence (new and old), evidence of other insect occurrence, distribution of discoloration, and any general information.

In table 1 these 50 trees have been roughly divided into three groups, namely, those within the New Jersey and New York infected area, those just outside of this area, and those occurring in the outlying infected areas.

Table 2.—Beetle occurrence in 211 diseased elm trees in seven plots.

Beetles	New Infestation		Old Infestation	
	Trees	Per cent	Trees	Per cent
Scolytus multistriatus	7	3	31	15
Hylurgopinus rufipes	8	4	32	15
Magdalis spp.	17	8	21	10

It is interesting to note, from the information gathered during this survey, that in three trees within the New Jersey—New York area no indications of any bark beetle or wood borer infestation, new or old, were found. In two of the six Indiana trees examined no indications of any infestation by *Scolytus multistriatus* or *Hylurgopinus rufipes*, new or old, were found. Only one *H. rufipes* gallery was found in the two Virginia trees, and no *S. multistriatus* occurred. No evidence of *S. multistriatus* was found in the Maryland tree.

Sanitation plots.—Dr. R. P. True of the Bureau of Plant Industry has established several plots, usually consisting of 30 elm trees, which had previously been marked for removal by the field scouts as dead and dying trees. We have examined seven of these plots for indications of bark beetle activity. These seven plots were all located outside the disease area; two in New Jersey, three in Connecticut, and two in New York. A total of 211 trees were examined. Of this total, 29 trees (or 14 per cent) showed new infestations. More detailed records are given in table 2.

Chemical treatment of elm stumps.—One of the outstanding problems arising from the present eradication program of the Bureau of Entomology and Plant Quarantine is to develop an effective treatment of the many elm stumps to prevent bark beetle attack and to prevent their sprouting. Experiments are now under way to find, if possible, some chemical or mechanical treatment of these stumps which will serve as a protection against bark beetle attack.

Insecticides.—Experiments with insecticides have been conducted in the greenhouse with a view to determining if their use could be applied in connection with the crotch-feeding habit of *S. multistriatus* adults.

Several arsenicals were tested, and of these magnesium arsenate killed the beetles more quickly than lead arsenate when both were used at the rate of 10 pounds to 100 gallons of water. Other arsenicals tried did not kill as quickly as these. It is recognized that a considerable problem presents itself in connection with such control. In order to be effective the poison must be quick in action and must remain on the twigs during a large portion of the growing season.

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PROGRESS IN DUTCH ELM DISEASE ERADICATION

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This year's activities have progressed in two stages. With the allotment in December 1934 of $527,000 of PWA funds for a winter sanitation campaign, personnel was soon organized to eradicate all standing, diseased trees, and to locate and destroy dead and dying elms that were potential sources of the fungus or likely breeding places for the insect vectors of the disease. Men for this work were secured from among those registered with the National Reemployment Service in the counties where the work was performed. As there were many experienced tree men unemployed at that time, the winter sanitation work was practically completed in the Connecticut and New York infected zones. About half the New Jersey infested area was similarly covered. Personnel employed during the peak of the winter's work averaged 1100 PWA employees and 60 appointed men on regular bureau funds. At the outset of the winter sanitation campaign there were 1325 confirmed trees standing, 1320 of which were in New Jersey, four in New York and one in Connecticut. By April 15 all trees then known to be infected with the Dutch elm disease had been destroyed. Early in May the initial allotment of emergency funds was exhausted and all temporary labor was dismissed on May 11. The winter and spring sanitation activities resulted in the destruction of approximately 430,000 dead and more than half-dead elms. Incidental to this work, there were discovered and eradicated 240 *Graphium* infected trees.

During April, preliminary adaptability tests were given to some 1700 referrals from the National Reemployment Service and members of eradication crews then working in anticipation of the organization of a large force to scout systematically for disease suspects. When an additional allotment of $250,000 was made available on May 28 by the Works Progress Administration, it was again stipulated that employees

should be secured through the National Reemployment Service, with the additional provision that 90 per cent must be from among those who were on the relief rolls during the month of May. This eliminated practically all men who had qualified in the adaptability tests. A 10 per cent exemption was provided for the selection, through the Reemployment Service, of experienced men to be used as supervisors. Rates of pay were considerably reduced in the new schedule and in many cases were unattractive to men whose experience was needed for supervision of the large force of untrained men to be employed. These same conditions applied to a further grant of $2,500,000 from WPA funds to this work late in July.

Aside from a nominal amount of non-systematic scouting by the permanent federal force, supplemented from June 8 to 28 by 50 two-man scout crews employed on an emergency New Jersey appropriation, the period May 11 to approximately July 1 was one of complete inactivity in the detection of the early-season and most characteristic symptoms of the disease. During this period, of 2500 suspects collected by experienced supervisors, 955 were confirmed as Dutch elm disease cases. Activity of overwintering adults of *Hylurgopinus rufipes* was reported on April 24, and *Scolytus multistriatus* beetles were observed emerging on May 10. Wilting characteristic of the disease was first observed in mid-May. Discovery of the first diseased elm as a result of foliage observations was made in the Bronx on May 16.

The only eradication work performed in the interim from May 11 until work was resumed late in June was performed by 25 six-man eradication crews carried on New Jersey funds from June 8 to 28, and 36 four-man crews working for 10 days starting May 25 on the New York state payroll. Lack of supervisors hampered continuance during this interval of CCC tree-removal activities.

Systematic scouting for *Graphium* infected trees, the second stage of this year's control activities, was performed from about July 1 to September 15. Organization of scout crews began the last week in June. Additional scouts were added until on August 24 there were 1038 crews in the field. Not until early in September did the number of employees on work relief funds reach its maximum of slightly over 3800 men.

Many difficulties presented themselves in the hiring, training and equipping of these scouts. In some sections it was difficult to secure even referrals from the local Reemployment Service offices. The men had to be trained to recognize an elm and distinguish symptoms of the Dutch elm disease. Field orientation, map reading and tree climbing were also included in their training. Even after assignment to a scout school, the number of men completing the course and qualifying for this type of activity was limited. Performance of the men for the first month was mediocre, due to their inability to distinguish between symptoms of the disease and other physiological factors that induce wilting. In some instances the scouts sampled large numbers of trees that would have been eliminated as non-*Graphium* by experienced scouts. In other cases the men failed to observe wilting apparently characteristic of the disease. While the large number of men available for scout duty may have par-

tially compensated for their inexperience, analysis of performance data indicates that their work did not approach that of experienced state scouts working during the same period and under comparable conditions. As the season lengthened, many of the men became more proficient in detecting the disease.

There was only one complete systematic scouting of the entire infected zone this summer. In addition, aproximately two-thirds of the infected area was covered twice and a few sections received three surveys. With a number of new infection centers requiring movement of the 10-mile area into outside territory, scouting of the protective band was limited to a single systematic survey of about 60 per cent of the area and a re-scout of 20 per cent of the territory. None of the 10-mile zone received the three scoutings originally scheduled.

Out of a total of 34,160 suspects collected since scouting began in May of this year, 6036, or 18 per cent, proved to be Dutch elm disease cases. On a state basis, 75 of these infections were found in Connecticut, 3851 in New Jersey, 2092 in New York, and 18 in isolated cities outside the major disease zone.

Speedy laboratory determination of suspects gathered by scouts was facilitated by a night messenger service, whereby daily collections were delivered to the laboratory before work began the following morning. At the peak of the summer's scouting 26 pathological workers were employed in suspect culturing. With the large force of men available it was possible to eradicate promptly all trees as confirmations were received. Very few days elapsed between confirmation of a tree, its clearance for removal by a state official, and its eventual destruction by an eradication crew. Due to delay in scouting this prompt eradication could not overcome the handicap of fungus spread by insect carriers emerging early in the summer.

In mid-July a new type of strip scouting was introduced whereby larger crews were deployed to scout systematically in woodland areas under the immediate supervision of men well trained as Dutch elm disease scouts. This materially increased the rate of coverage in sections adapted to this type of scouting.

This year four additional diseased trees were found at Old Lyme, New London County, Conn., within 100 feet or so of the single confirmed tree discovered there last year. Prompt eradication of these diseased trees was supplemented by a recently completed intensive sanitation project in that general vicinity, involving the pruning of 1149 elms to eliminate wood that might serve as breeding places for *Hylurgopinus rufipes* known to be numerous in that community.

Systematic scouting in the major infected zone was concluded on September 15, at which time there were drastic reductions in the personnel of each state. From a total of around 3800 men employed on relief funds, the force was reduced to approximately 2100. Most of the men retained were assigned for several weeks to the location and tagging of dead and dying elms, after which they were transferred to eradication crews. A further reduction in force was made during the week of October

12. On November 4, men were added to conform to a revised winter quota of men to be carried on WPA funds.

In conjunction with the summer's activities there were removed an additional 210,000 dead and dying elms, bringing the total of elms of this type destroyed since the sanitation work was initiated last January to over 650,000. There are at present approximately 450,000 devitalized elms tagged for future removal.

About July 15, five scout supervisors were dispatched to the outlying cities where diseased trees had been found in previous years. These supervisors did systematic scouting around the old disease centers in Baltimore, Cincinnati, Cleveland, Indianapolis and Norfolk. Automobile scouting was performed in nearby sections exposed by the disease when imported burl-elm logs were transported to veneer factories. When additional funds later became available, scout supervisors were sent to New Orleans, Knoxville, Louisville, Kansas City, Chicago, Dayton, Philadelphia and Boston. Each supervisor organized a scout crew from men secured through the local employment service offices. A maximum of 104 relief workers was hired for this purpose. These supervisors and crews collected a total of 986 suspects, from 18 of which Dutch elm disease fungus was cultured. Most of the distant scouting was abandoned late in September.

Of the 18 confirmed trees discovered this summer in cities remote from the major diseased area, 10 were in Indianapolis, two each in Cleveland and Norfolk, one at Portsmouth in the same general region as the Norfolk infection, and three in Brunswick, Md. All of these trees have been felled and burned. With continued scouting in these cities the isolated infections may be destroyed before a major epidemic develops. The Brunswick trees, located approximately 50 miles from the confirmed tree discovered in Baltimore in 1933, comprise the only new isolated infection center found during the current year's outside scouting activities. Brunswick is a center for freight reloading and is one of the transfer points through which imported burl-elm logs passed enroute to veneer mills. A supervisor and crew scouting railroad rights of way out of Baltimore located the first diseased tree found in Brunswick.

This season nearly 400 fewer confirmed trees were found than in 1934. Infections discovered during the summer of 1934 and the subsequent winter's sanitation project numbered 6428. Since discovery of the disease in this country in 1930 a grand total of 13,969 cases of infection by this disease has been found. Only 39 recently confirmed trees remained standing at the end of October.

As a result of this summer's scouting the known infected zone has been increased 47 per cent. The largest proportionate increase is in New York, where confirmed trees found outside the 1934 known infected zone resulted in the area's increase from 852 to 1495 square miles. An increase from 224 to 283 square miles in the Connecticut infected zone was occasioned by the discovery of diseased trees in Putnam county, N. Y., which pushed out the line connecting the farthermost infected trees. Actually there were no confirmed trees found outside the Connecticut infected zone as determined during 1934. There was a moderate increase,

from 1402 to 1862 square miles, in the New Jersey infected area. There is now a total of 3640 square miles included in the major diseased area. The 10-mile protective band surrounding the infected zone comprises an additional 2185 square miles. This 10-mile protective zone includes 145 square miles in New London and Middlesex counties, forming a semicircle surrounding the point of infection at Old Lyme. As all confirmed trees at this point were found within approximately 100 feet of one another, no square mileage has been added to the infected zone to include this point. There is a slight decrease in the extent of the protective area, due to contour changes and the fact that last year's area was more than 10 miles wide in some sectors. The present work area of 5825 square miles is therefore only 21 per cent greater than the territory in which operations were carried on in the fall of 1934.

All diseased elms found in the tristate area outside the previous year's infected zone are within a radius of 50 miles from Columbus Circle in New York City. In this respect the zone of infection remains unchanged, the new infection centers of this season merely rounding out sectors in which the disease had not previously been determined.

An amendment to Foreign Quarantine No. 70, effective January 1, 1935, prohibits the importation of elm veneer logs, by means of which the disease gained entry into the United States. A new domestic quarantine, No. 71, imposes a rigid embargo on the movement of all plants or parts of plants of all species of the genus *Ulmus* from the known diseased area in Connecticut, New Jersey and New York. State quarantines prohibiting the intrastate movement of host material from the infected sections are also in operation.

Mutually helpful cooperation has been accorded this project by officials of the three infected states, and unanimous public support has greatly assisted in furthering the eradication activities.

This winter we are attacking an important infection center in the diseased zone by clean cutting an area of six square miles known as the Great Piece meadows, located in Essex county, N. J. The research organization engaged in the study of this disease has conclusively shown that the fungus is transmitted throughout root grafts between elms growing near one another. This root grafting may take place between elms some distance apart, dependent upon the extent of the root systems. In the wooded section of the swamp area where this work is in progress, root grafting is common. Scouting of individual trees and destruction of those showing visible symptoms of infection in such areas will not accomplish eradication of the disease when infection is spreading through underground root grafts. Many trees in the swamp land are so devitalized that recognition of disease symptoms is quite difficult. High water at certain periods of the year also prevents systematic scouting therein. The unthrifty condition of the elms in these sections indicates their inadaptability to growth under such conditions. The additional fact that they have been ignored during logging operations attests to their lack of value for timber. Removal of 30 dead and dying elms from among the elm population in a test plot in the meadows showed that 17 per cent of the decadent trees were infected with the disease. Con-

sequently the gradual removal of elms as external symptoms show them to be diseased would still leave an underground residue of living fungus, resulting eventually in infection of the entire elm population and a greatly lengthened period of eradication. Inasmuch as a chemical has been recommended by the research workers that is effective in killing stumps and preventing subsequent sprouting, it is practicable to clean cut an area, thereby destroying this species in the elm-free zone for a period of several years. In this way scouts will be relieved to scout systematically in sections with valuable elm populations. Incidentally, in rendering this area elm free, thereby removing a large proportion of decadent elms along with more thrifty specimens, an extensive population of insect vectors of the disease is at the same time destroyed.

Although for several years men have been furnished to the bureau by the Emergency Conservation Work Administration for the removal of diseased and dead and dying elms, the contribution of this branch has been more definitely organized by the establishment during August and September of five CCC camps devoted exclusively to Dutch elm disease control. These units will make a decided contribution to the eradication and sanitation activities. The camps are located at West Milford, Passaic county, and Raritan, Somerset county, N. J.; West Haverstraw, Rockland county, and Highland Mills, Orange county, N. Y.; and near Danbury, Fairfield county, Conn. A sixth camp is under construction at Denville, Morris county, N. J. When organized to their capacity the total number of enrollees in the five camps now operating will be 873 men and 49 supervisory foresters. Dutch elm disease control activities of the CCC workers are supervised by experienced men trained and recommended by the Bureau of Entomology and Plant Quarantine.

FURTHER STUDIES OF THE USE OF RADIO WAVES IN INSECT CONTROL[1]

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Introduction.—Radio waves are the result of pulsations of electric energy. The electrostatic field is a space having depth, width and thickness, bounded by two electrodes of various forms. The electrostatic fields with which we have worked have been bounded by two aluminum plates of various sizes, which we may for convenience indicate as plate A and plate B. These plates are activated by an oscillating electric circuit. For a short period of time the electric charge builds up on plate A, which, at that time, is positive in sign. This building up reaches a maximum and then decreases. As the charge in plate A is decreasing the charge on plate B is building up, which in turn, is positive. The charge in plate B builds up as the charge in plate A diminishes until such time as the charge on

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plate B has reached a maximum and the negative charge on plate A has reached the minimum. This alternate building up and decreasing in electric charge on the plates of the electrostatic field imparts energy to the surrounding space and this energy travels outward in all directions except as interfered with by absorbing substances which naturally are located in the field. How this energy is carried is a matter which is largely unsettled but that it does progress from the point of initiation outward is adequately demonstrated by the fact that a receiving instrument located at greater or less distances is able to pick it up and recognize it for what it is.

Within the electrostatic field lines of force are established between the plates. We do not know much about the nature of these lines of force but they appear to be similar to the lines of force exerted between the poles of a magnet. With the alternately changing charge of plates A and B, lines of force change, the positive sign appearing first in this plate and then in the other plate.

It is thought that this change in polarity of the lines of force induces the change in molecular polarity in the materials placed within the influence of the electrostatic field. It is thought that this change in polarity involves matters of intra-molecular friction and consequently generates heat.

It is definitely known that substances placed within the electrostatic field do absorb energy and do develop heat. It is definitely known that substances of high electrical conductive power do not heat readily. Such a substance is copper. It is definitely known that if copper is broken up into small particles, the surface of which has been allowed to oxidize, that copper under this condition does absorb energy and does heat rapidly. It seems that any material having poor electrical conductivity which is placed within the influence of the electrostatic field does absorb electric energy and does transform it, at least in large part, into heat, while on the other hand, any substance that has high electrical conductivity, if it does absorb electric energy, quickly gets rid of it without the production of any considerable amount of heat.

Nature of the insect-killing agency.—In the electrostatic field activated by the oscillatory current, there is a constant shifting of electric charge going on and a constant shifting of the polarity of the lines of force. The electrodes are alternately positively charged. These pulsations of electric energy, involving pulsations of the lines of force, may be represented as a wave, the crests of which represent the maximum charge and the troughs the minimum charge. This wave is regular in form and is known as a sine wave. It is this type of electrical pulsation with which our work upon insects has been done. The distance from crest to crest of the sine wave is a matter of the period of time which elapses between the maximum of one pulsation and the maximum of another pulsation. The actual dimensional length is determined by the fact that this energy emission proceeds outward at the rate of light, or 186,000 miles per second. Thus, if a period of one-tenth of a second elapses between the crests of this sine wave each wave itself has a dimensional length of 18,600 miles. If the period of time is one millionth of a second the

dimensional length of the wave would be .18 mile. Wavelength is thus seen to be the result of the rate of pulsation or frequency of pulsation. Therefore, the greater the frequency of pulsation the shorter the dimensional wavelength, and the less the frequency of pulsation the greater the dimensional length of the wave. Wavelength and frequency are thus seen to be intimately related, the former depending fundamentally upon the latter.

The speed of change of polarity in the lines of force likewise depends upon the frequency of pulsation and in this way frequency will affect

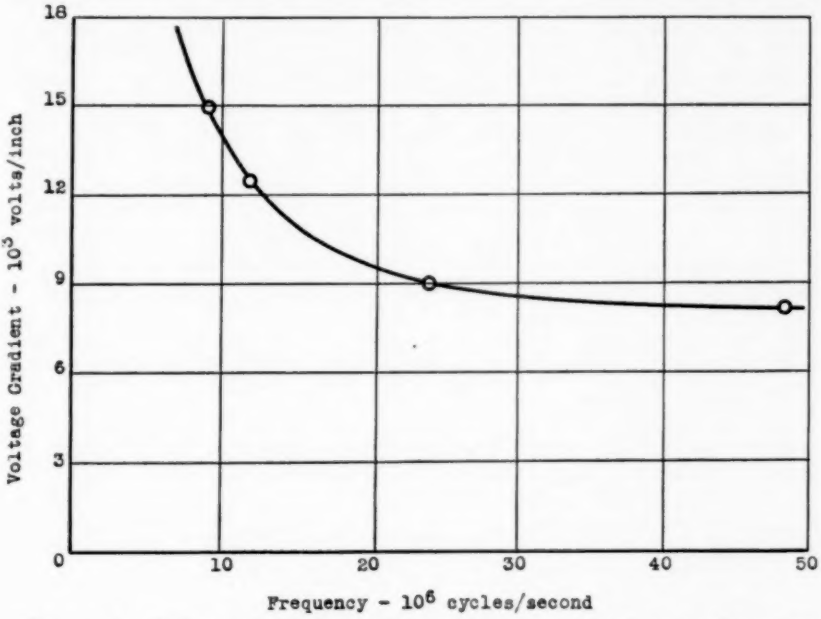

Fig. 1.—Relationship of voltage gradient to frequency for kill of *Tribolium confusum* adults in air, in 30 seconds.

any insect placed within the influence of the electrostatic field. Fundamentally, the insect is affected by the electric energy in the electrostatic field only insofar as this energy is absorbed and is not passed on. It has been shown that absorption is dependent upon electrical conductivity and the dielectric constant of the material concerned. Now, the insect is a heterogeneous substance, the various compounds of which have differing electrical conductivities and dielectric constants. It is, therefore, impractical to determine absorption by calculation based on these two factors. The amount of energy absorbed by the insect must be determined by measurement of energy lost when the insect is in the electrostatic field in comparison with the energy loss when the insect is not in the electrostatic field, or such portion of the absorbed energy as is transformed into heat can be measured by temperature increase in the in-

sect's body. The second method, of course, is incomplete in its results because it fails to take into consideration the energy lost through heat radiation, as well as energy used within the insect's body without the production of heat.

All of the data, derived on the question of how the electrostatic field kills insects, when summarized, seems to indicate that injury to the insect is due to the accumulation of a lethal degree of temperature within the insect's body. This data also indicates that this lethal degree of heat is not reached except as the rate of heat accumulation is materially faster than the speed of heat radiation from the insect's body. Of course, it must be recognized that this work has been done under frequencies ranging from a little below a million cycles per second to a trifle over 100 million cycles per second and that the data might be different if frequencies of the Hertzian waves could be propagated with power.

Interrelation of wavelength, frequency and voltage gradient.—Extensive published data indicate that the amount of energy absorbed by the insect in the electrostatic field depends upon the frequency of oscillation and the voltage gradient or power with which it is applied. The higher the frequency the more readily occurs the absorption of energy by the insect body. The higher the voltage gradient the more rapid the absorption by the insect body. These relations are indicated graphically in a plotting of data obtained from a study of the effect of varying frequencies and voltage gradients upon the adult of the confused flour beetle *Tribolium confusum* Duv. In this study the constant was a period of 30 seconds from time of beginning of application to death. The curve is shown in fig. 1. This figure shows that the lower the frequency the greater the voltage gradient required to accomplish the death of the insect and that the higher the frequency the lower was the voltage gradient required to accomplish the death of the insect. Of course, the frequency range covered from a little over six million cycles per second to 48 million cycles per second. The rapid change portion of the curve, of course, lies between six million and 23 million cycles per second. The slow change of the curve lies between 23 million and 48 million cycles per second. Whether this flattening out of the curve means that beyond 48 million cycles per second there are no further rapid changes in requirement of volts potential cannot at this time be answered because apparatus adequate for power production at the higher frequencies is both difficult to secure in the market and difficult to build in the laboratory.

Nature of the differential effect of plants and animals.—Since it has been shown that differing substances absorb electric energy in the electrostatic field upon the basis of their electrical conductivities and dielectric constants, and since these factors vary widely, it is to be expected, and it has been found by experiment to be true, that different substances absorb energy and develop heat at differing rates. Inorganic and organic compounds, living plants and animals naturally exhibit this variation in the rate of energy absorption and in the development of heat.

In general, the results of our investigations have shown that plants absorb electric energy and develop heat less rapidly in the electrostatic field than do insects and that a wonderfully adequate differential occurs

between the time of exposure necessary to kill an insect infestation and the seeds and grains on which this infestation is feeding. When, however, we pass over into the treatment of actively growing plants, this differential becomes greatly reduced and sometimes altogether disappears.

Not only do the members of different insect orders, families, genera and species show differing rates of heat development but differences appear in different stages of the development of the same insect and in different individuals of the species in the same stage of development. The difference in rate of developing heat, which occurs between different individuals of the same species, is much smaller than that which occurs between different stages of the same insect. When, for different individuals in the same stage of development, the critical voltage gradient has been reached, the difference in the voltage gradient necessary to increase from 90 to 100 per cent kill is small, being of the order of 9 per cent increase in volts potential, while the difference in voltage necessary to kill the egg as compared with that necessary to kill the larva is much greater, being of the order of 200 per cent that necessary to kill the larvae. Basing conclusions on information obtained from dealing with *Bruchus obtectus* and *Tribolium confusum*, the order of difficulty in obtaining kill in the electrostatic field, beginning with the most difficult and proceeding to the less difficult, is egg, larva, pupa and adult.

While it is undoubtedly true that there exists a difference in the rate of internal heat development in different stages of the same individual, in different individuals of the same species, in different families and orders of insects and in plants as compared with insects, it has been found also to be true that it is ordinarily necessary to bring the food in which the insect is feeding and by which it is more or less sheltered to a temperature which is lethal to the insect in order that all stages of the insect infestation may be destroyed. If a living plant is involved and is in the seed stage, the lethal temperature sufficient to destroy the insect usually produces no effect whatever upon the plant or stimulates it to more pronounced germination activity.

Possible modification of the effect of electrostatic field upon insects subjected to its influence.—It must be remembered that throughout the studies on which this paper is based the effect of radio waves upon insects has dealt with the sine wave only and in a frequency period from less than one million to 100 million cycles per second.

Of course, such frequencies could appeal to the normal frequency of nothing other than molecular aggregates. No especial effort has been made to correlate the molecular aggregate dimension with the rate of heat development in these aggregates. It may, therefore, be said that no real study of resonance phenomena has been made in the course of this work thus far. This leaves the probability of increasing the effect of the electrostatic field on insects through resonance entirely untouched.

Furthermore, no effort has been made in the course of this study to modulate the sine wave, thereby leaving open another method of modifying the effect of radio waves upon insects treated in the electrostatic field.

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INSECT AND DISEASE EVALUATIONS IN POTATO EXPERIMENTS

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In order to study the effects of the different insect pests and diseases which combined to influence the final yield of potatoes in various experiments, the following studies have been made. Previous to making any correlation calculations, a model or figure was constructed.[1] This is shown in fig. 1. The average yield, number of hopper-burned leaflets per plant, number of leaflets per plant showing early blight lesions, and number of flea-beetle holes per leaflet from each spray treatment made in 1932 were the data on which the studies were based.

The average number per plant of leaflets showing early blight and the average number of flea-beetle holes per leaflet are shown graphically on the floor surface of the model. The lengths of the various flags represent the average yields diminished by a constant of 200 bushels. This accounts for the extremely short flags in some cases. The heights of the flags show the average number of hopper-burned leaflets per plant. The letters and figures at the base of each flag indicate the treatment which that flag represents. The explanation of the symbols are as follows: U, untreated; B, Bordeaux mixture 5-7-50; C, calcium arsenate combined with 5-7-50 Bordeaux; D, 20-80 copper-lime dust; S, Bordeaux spray 4-4-50; 8-8, Bordeaux 8-8-50 concentration; 4-4, Bordeaux 4-4-50 concentration; 2-2, Bordeaux 2-2-50 concentration; 1, 2, . . . 10, the number of applications of 5-7-50 Bordeaux applied during the season.

The plants which have the fewest leaf injuries as shown in the foreground corner of the model in fig. 1 have the longest flags. Other plants which have few leaf injuries also have long flags or comparatively high yields. As the distance increases to the more distant corner of the model, or point of most injuries, the flags generally become shorter. A side view of the figure would show almost a straight line of the flag heights, or hopper-burn, arising from the point of fewest early blight injuries and increasing in height to the point of most early blight injuries. This indicates a close relationship between the two variables, hopper-burn and early blight. An end view of the figure would show an order of increase of flag heights from the side of fewest flea-beetle injuries to the side of most injuries. This shows that many flea-beetle holes were not as intimately associated with many hopper-burned leaflets or with many leaflets showing early blight as was true of leaflets affected by hopper-burn.

The relationships between the four variables plotted in fig. 1 appear to

[1] Acknowledgment is given to Dr. W. J. Youden, of the Boyce Thompson Institute, Yonkers, N. Y. for suggestions which have been of great value in the work here presented.

have assumed a straight line function. Changes in the dependent variable (yield) are thus assumed to be accompanied by changes of exactly the same magnitude in the independent variables, thereby determining the methods (*2*) of analyses fitted to express the proper relations.

The data which were used to construct fig. 1 were treated statistically according to the methods outlined by Wallace & Snedecor (*4*) and gave the results indicated in table 1. There were 22 observations and four variables, thus giving 18 degrees of freedom.

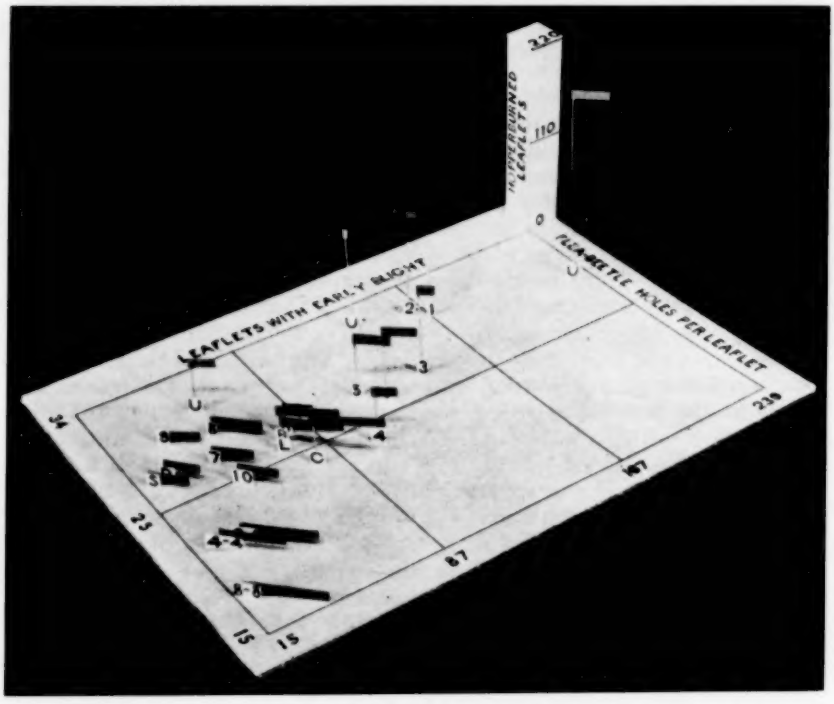

Fig. 1.—Graphic representation of the relationships of early blight leaflets with hopper-burn, flea-beetle holes per leaflet and yields in bushels per acre, together with the treatments administered to the plants from which the data were taken. See text for explanation of the symbols.

It appears from the r values of $-.56$ and $-.58$ that hopper-burn and early blight bore almost equal relations to the yields. The r value of $-.75$ for yield and flea-beetle holes indicates an actual correlation. This seems to agree with the report given by Anderson & Walker (*1*) who also obtained a correlation between potato yields and potato flea-beetle injuries. The coefficient of correlation r of .96 for hopper-burn and early blight is high and accounts for .92 of the total variance. This association may be a casual relationship or possibly a more significant one in which the potato leafhopper is an important agent causally affecting the spread

or pathogenicity of the early blight disease. Flea-beetle holes appear to be not correlated with hopper-burn or with early blight. According to Johannsen (*3*) early blight lesions and flea-beetle punctures were believed to have a very close association. The beetles were thought to be vectors of the disease or of providing a means of entrance for the fungus into the potato leaflets. The multiple correlation coefficient R, which measures the association of all factors combined against the yield, gives a highly significant value of .78.

The relative effects of flea-beetle feeding injuries on yields are shown to be significant in comparison to hopper-burn and early blight. This may be partially accounted for by the extensive and continued attacks by the flea-beetles, even on plants well sprayed with the poisonous materials used in the tests.

Table 1.—Relationships of hopper-burn, flea-beetle holes, early blight lesions, and yields in potato experiments.

COEFFICIENTS OF CORRELATION[2]	
Yield and hopper-burn	r–.56
Yield and early blight	r–.58
Yield and flea-beetle holes	r–.75
Hopper-burn and early blight	r .96
Hopper-burn and flea-beetle holes	r .53
Early blight and flea-beetle holes	r .53
COEFFICIENT OF MULTIPLE CORRELATION[2]	
Yield, hopper-burn, early blight, flea-beetle	R .78
RELATIVE EFFECTS OF HOPPER-BURN, FLEA-BEETLES, AND EARLY BLIGHT ON YIELD	
Hopper-burn	1%
Early blight	28%
Flea-beetle holes	71%

Summary.—The yield of potatoes is depicted as being influenced by injured leaf surfaces resulting from attacks by leafhopper and flea-beetle insects and from early blight disease. Graphic representation shows that the largest yields of potatoes were obtained from plants showing the fewest leaf injuries. As the number of leaf injuries increased, the yield decreased in a linear relationship. The largest yields tended to come from those plant treatments which received the most bordeaux mixture. Flea-beetle holes were statistically significantly associated with the yield and were not significantly associated with hopper-burn and early blight. Hopper-burn was significantly associated with early blight.

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[2] The value .59 is required for significance, and .68 for high significance, for r and R, as given by table 16 of Wallace & Snedecor (*4*).

ECONOMIC CONTROL OF *MAGICICADA (TIBICIAN) SEPTENDECIM* L. IN A GROVE OF CENTURY-OLD OAKS

(CICADIDAE—HOMOPTERA)

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Brood IX of the periodical cicada *Magicicada (Tibicina) septendecim L.* appeared in southeastern West Virginia in dense swarms in 1935. The boundaries of the dense swarm area may be briefly outlined as follows: beginning at the West Virginia-Virginia border due east of Marlinton in Pocahontas county and continuing due west to a point ten miles southwest of Summersville in Nicholas county, thence due south to a point near Ansted in Fayette county, thence southwest to Echart in the southeastern corner of Boone county, thence southeast to Herndon in Wyoming county and thence due south to the West Virginia-Virginia border near Jenkinjones in McDowell county. From this line, in all outward directions, the number of individuals rapidly decreased, so that from 10 to 25 miles beyond this dense swarm area the limits of the brood are passed except for scattered individuals occurring throughout the state. These boundaries were determined by personal scouting and by reports from foresters, county agents and other interested parties.

Located at White Sulphur Springs in the northeastern corner of the dense swarm area, is the beautiful and world-renowned Greenbrier hotel of White Sulphur Springs, Inc. This pleasure resort is located in a valley surrounded by high wooded mountains and immediately surrounding the hotel is a grove of magnificent old oaks.

This formed a perfect setting for the maximum infestation of the periodical cicada and the authorities of the Greenbrier were very much concerned over the possibility of damage to these oaks.

Method of control.—Under the direction of R. H. Patterson, consulting engineer in charge, the trees were banded with common fly tanglefoot and the cicadas that massed below the bands collected and burned. Two or three bands of the tanglefoot were placed around the trunks about as high above the ground as a man could reach, or just below a crotch.

The bands on the tree in fig. 1 were lowered in order to obtain a close-up view and to be able to show simultaneously the insects on the trunk as well as the method of placing the bands. These bands slowed up the ascension of the larvae and allowed a greater lapse of time between each removal of the insects. This was done by scraping the trees with a bamboo rake, such as is used for raking clipped grass, and by collecting the insects in buckets. All the individuals collected were burned.

Observations.—Larvae began emerging on May 21 and continued until June 18. There was a gradual increase in the number emerging up to May 31, after which the number gradually declined. A few nights prior to May 31 were cold and emergence almost stopped. No record was kept

of the numbers collected each day but approximately 145 bushels were collected during the period of operation. Many were trampled under foot by the workmen, the number being estimated at 25 per cent of the total number emerging. In all, 193 bushels of the insects were estimated to have been destroyed.

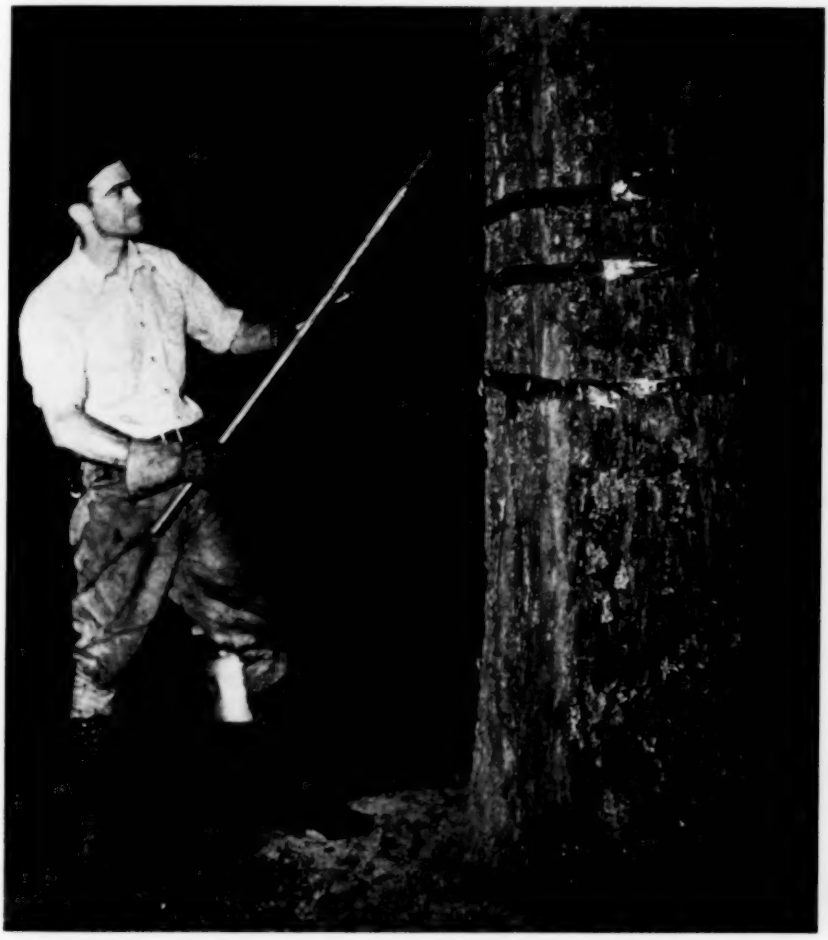

Fig. 1.—Collecting the cicada larvae and adults. This night picture shows the way in which the insects are removed from the trunk of the tree. Encircling the trunk are tanglefoot bands.

The number of individuals collected, judging from counts of the individuals in a quart, is estimated to be from 1,235,000 to 1,544,000. Counts of individuals in a quart varied from 200 to 250. The area protected contained approximately 30 acres. The number of individuals collected, therefore, was only one to each 1.05 square feet or to .84 of a

square foot of surface area of the soil. Compared to infestations in other groves, judged by the holes in the bare ground, this infestation was fairly light. Three such holes to a square foot were common in many groves in the dense swarm area and 84 emergence holes to a square foot is reported by Marlatt.[1]

Cost.—The labor involved and the cost of this operation can only be estimated. Full-time employees were used and no separate labor records were kept. Mr. Patterson estimates that five to seven men were regularly employed from 6 p.m. until 1 a.m. The work continued for a month so that a figure of six man-months is about as near as the labor can be figured. Paying the men $100 per month would place the cost of the operation at $600.

Results.—The results were excellent. The grove was visited during the first week in July, and at that time only a few damaged twigs were visible. There had been a storm a day or two previous and it was reported that a few twigs had blown down. An examination a few days earlier would no doubt have resulted in a few more damaged twigs being observed.

Similar groves in the dense swarm area, the first week in July, exhibited hundreds of dead twigs to a tree. Assuming the oaks at the Greenbrier would have been similarly damaged, the control obtained by this operation was very effective. The authorities of the Greenbrier were very well pleased with the results.

Discussion.—The protection afforded these trees by the operation described herein indicates that the adults do not travel far from their point of emergence from the soil under the conditions that surrounded this grove of oaks. The 30-acre area under control was shaped somewhat like a boot. Immediately on each side of the mouth of this boot, 1000 feet apart, were two wooded knolls rising 50 feet or more above the protected area. Cicadas were fairly thick in the trees on these knolls yet there was no evidence that any perceptible number moved into the area.

The fact that the adults do not appear to move any great distance and that few larvae hatched within the area, leads me to believe that there will be very few adults emerging in this grove in 1952 or thereafter, and that the control operations employed this year will rid the grove of this insect for all time. It will be interesting for someone to check this point in 1952.

Certainly the results obtained warrants recommending similar practices in other valuable groves of trees.

I am indebted to Dr. L. M. Peairs, entomologist, West Virginia University, for encouragement and advice in assembling the material and in the composition of this paper, and to Mr. R. H. Patterson, consulting engineer, White Sulphur Springs, Inc., for permission to publish these results.

[1] **Marlatt, C. L.** 1907. The periodical cicada. U.S.D.A., Bur. Ent. (new series) Bul. 71:99.

NOTES ON A JAPANESE WEEVIL, *CALOMYCTERUS SETARIUS* ROELOFS, IN CONNECTICUT

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This otiorhynchid weevil is a rather recent addition to the American fauna and was probably introduced sometime prior to 1929, but just where, when and how is not known. It was described from Japan by Roelofs in 1873. This insect is one of the apterous group of the Otiorhynchidae and does not fly, so that its spread may be expected to be rather slow. Apparently nothing is known of its life history or its immature stages. As far as I have been able to learn, there are few references to it in any American literature.

At the present time this weevil is known to be present in New York, Pennsylvania, Maryland and Connecticut. It was first reported from Yonkers, N. Y., in 1929, by Mr. A. J. Mutchler (*6b*) of the American Museum of Natural History. At that time the insects were feeding on Japanese ivy, rose bushes, geraniums and woodbine and doing considerable damage to American ivy and woodbine. Later they were very abundant and were attracted to the sides of a light-colored house and became a nuisance by entering the house even though the doors and windows were screened.

At the present time there are seven known infestations in Connecticut in the towns of Sharon, Salisbury, Stratford and Greenwich.

In 1930 this weevil was reported from Lakeville, Conn. (*1a*). At that time the insects were abundant on the southwest side of the house and many of them had entered the house. In the garden that summer, Swiss chard, roses and iris showed the characteristic feeding. Most of the feeding is done by eating out round notches in the margins of the leaves so that the leaves have a scalloped appearance. The owner of the house sprayed the adults where they were congregated on the side of the house, using kerosene emulsion, and killed large numbers of them. This fall the owner reported slight feeding on Swiss chard, and in September I noticed a little feeding on Deutzia leaves. Spraying with kerosene emulsion has been practiced each summer and at present the infestation is less than it was in 1930.

This past summer weevils were very abundant in Sharon, Conn. (*1b*), about four miles from the Lakeville infestation. The owner of the Sharon place reported that they have been present for two or three years. This house was built in 1929 and the building materials, such as lumber, sand, stone and cement, were trucked from Lakeville, and the owner thinks that the weevils may have been introduced in this way. As the adults are wingless and cannot fly, it is possible that they may have been brought from Lakeville in this manner, or they may have come from somewhere else on potted plants, nursery stock or other material.

At this infestation adults began to appear in late June and a few were still present on September 10. They were most abundant during the last

half of July and the first half of August. Agreeable to their usual custom, they gathered in large numbers on the south side of a white house, where the owner killed them with a rotenone spray. In spite of all the spraying, large numbers of them entered the house and were swept up and killed each day. Adults were also present in the garden, where they were feeding on several kinds of plants. In a small greenhouse and in cold frames many varieties of plants were slightly eaten, and the adults were particularly fond of English ivy.

In a commercial greenhouse at Sharon, adults were seen all summer but were not very abundant and did very little damage. In September a few weevils were still present on chrysanthemums. On these plants the adults were chewing into the flower buds.

The third infestation in Sharon was on a private estate and was first observed in 1935. Adults were not very abundant and injury was noticeable only on ampelopsis growing on the side of a white house. On September 10 no adults could be found.

The two Stratford infestations might be considered as one. Two places, about 200 yards apart, were infested. They are rather new houses in a shore development. In both cases adults were swarming on the sides of the houses. One house, where the adults were most abundant, had no shrubs or plants near it. The only vegetation present was a lawn around the house. The other place had a variety of plants near the house, and roses, Deutzia and ivy were injured somewhat, especially the roses. At this house many adults were present in the cellar, and the owner informed me that plants were stored there during the winter.

The Greenwich infestation was discovered accidentally. The house was reported infested with termites by the tenants during the summer, but the owner did not ask us to examine the house until October 28. At that time he told us that his tenants reported insects crawling on the side of the house, which they supposed were termites. They washed them off with a hose but said that the next day they were again present on the side of the house. A careful examination of the south side of the house was made and a few dead *Calomycterus* weevils were found in spider webs. Very little characteristic foliage injury could be found except slight feeding on forsythia bushes and on a small maple seedling.

There are no available references to the life history of this weevil nor to any of the immature forms. Judging by the life history of allied weevils, it is fair to assume that the larval stages are spent in the ground. Soil was collected from both Sharon and Stratford. This was taken to the laboratory and examined for eggs and larvae but neither were found. The soil was taken near where adults were most numerous and included pieces of sod and a pot of soil from a greenhouse where adults were plentiful.

Dr. E. N. Cory (*2b*) reports its presence in Towson, Md., July, 1935, where thousands of beetles invaded two houses. They had been feeding on a wide variety of plants: roses, milkweed, clover, hollyhock, *Hemerocallis*, redtop, ivy, marigold and *Pyracantha*. The owner of one of the houses said that the infestation was present in 1934.

Specimens of this weevil were received for identification at the Ameri-

can Museum of Natural History. These were sent from the vicinity of Allentown, Pa., where they were found crawling on grass and the sides of houses. Guyton & Champlain (*3*) report its presence in Mechanicsburg, Pa., where adults were present on yarrow and sweet potatoes and were causing some injury to the latter plant.

It would be interesting to know how these weevils were introduced into the United States and how they spread from one state to another. Dr. Cory suggests that as no adults were seen mating where they were abundant, nor in breeding cages, they may be parthenogenetic, and that may account for their rapid increase. Possibly searching for these weevils might result in finding them present in many other localities. It is possible that this weevil may become abundant enough to be of economic importance.

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TERMITE DAMAGE IN CONNECTICUT

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In the fall of 1931 and the spring of 1932 several cases of termite[1] injury to houses were reported to the experiment station (*1a*). Prior to that time records of such injury were not very common (*1b*). In 1934 many cases of termite injury were investigated, and a report given (*2*). This report covered 24 requests for termite examinations, and in all cases the buildings were found infested. In 1935, 105 infested buildings were examined in all sections of the state. Damage has varied from replacements costing a few dollars on wooden porches and steps, to several thousand dollars for replacement and protection in a three-story brick building with wood floors and wood partitions. Ten old houses, many of them colonial dwellings, were in danger of immediate and serious structural failure, and two modern buildings were also seriously damaged structurally. In one of these latter buildings much temporary shoring was necessary to satisfy the building inspector as to the safety of the building. Our estimate of the amount necessary to replace damaged wood and in the most serious cases to install metal barriers to prevent further damage was $100,000 for these 105 infested buildings. We know

[1] *Reticulitermes flavipes* Kollar.

that 16 infested buildings were repaired or are in the process of repairing at a total cost of $47,000. Nine of these buildings required $38,800 for repairs and termite-resistant construction. These figures include only buildings that we have examined and know were repaired. They do not include any work done by commercial concerns not using structural methods of control, nor any estimates of damage to buildings not examined by us.

The distribution of the infestations is interesting. In four places, entire city blocks of residences or commercial buidings are heavily infested. In one location, 14 of 19 buildings owned by a hospital are infested, six being badly damaged structurally. Six mansions located within an area of one city block in another locality are all infested, some being seriously damaged. A block of small shops in New Haven was found infested last spring after a very large swarm of adults had appeared along the entire frontage. In another part of the same city, six dwelling houses, all that occur in the block, are infested. Of course these are isolated cases, and cannot represent true conditions, since we also know of large blocks

Table 1.—Termite entry in buildings.

Point of Entry	Number of Buildings	
	Modern	Old
Direct contact between wood and soil		
Sills, cellar windows, porches, posts, etc. in contact with soil	50	30
Sills or joists underneath filled masonry porches in contact with fill	19	0
Through cracks in foundation or basement floor	23	24
Through tubes constructed over foundations	4	2
Totals	96	56

of houses in which no termites have been found. However, the intensity of the attack in certain places and the widespread occurrence of damage has convinced us that we are facing a serious proposition.

The actual point of entrance of the termites has been determined in most of the buildings that have been examined. The results are given in table 1, and show that a majority of the buildings are infested through wood in actual contact with the ground. A smaller percentage of entries occurs through cracks in the foundations or basement floors. Entry through tubes on foundations has been comparatively rare, and in most cases did not account for the only entry in the building. This analysis shows clearly that architects and builders must pay more attention to building construction in order to prevent widespread termite damage. The fact that almost 70 per cent of the entries in modern buildings were in wood in actual contact with the ground indicates that those responsible for building construction have ignored sound construction methods in many instances.

Termite control companies.—In 1933 one termite control company started work in Connecticut, using control methods based on recommendations of Dr. Thomas E. Snyder of the federal Bureau of Entomology. This company depends mainly on metal shields together with other structural changes to exclude termites from buildings. At present there are two such companies in business in Connecticut, in addition to

several building contractors doing this type of termite control work. In 1934 and 1935 several companies using chemical control methods started operations in the state. These operators depend almost entirely on soil treatments, pressure impregnation of timbers through small holes drilled at occasional points, or both types of treatment. Some of these concerns use advertising and sales methods that are very questionable. Some of them give "guarantees" of their work for a five-year period. Apparently these "guarantees" merely mean that the companies will make no further charges for any work they do within the five-year period. Since none of the companies have been operating in the state for a five-year period, it is impossible to pass judgment on the effectiveness of any of the treatments at the present time. We do know of certain disadvantages and chances of failure of this type of treatment. In the first place, there are no definite records of successful use of soil treatments in New England with the exception of the use of Phinotas oil by O'Kane & Osgood (*3*). In their test the soil treatment was applied in connection with structural changes in the building in question. Paradichlorobenzene failed to stop termite activity in one case in New Haven, although it was used at double the recommended strength. We understand that orthodichlorobenzene proved useless in one test in the vicinity of Boston. We feel that arsenicals should not be used under any buildings, and that they should be used with great care outside buildings. Moreover, we know of no unbiased tests in New England which have proved the effectiveness of arsenical soil treatments.

Treatment of timbers in place is a difficult process. There is no question that some of the materials on the market will penetrate wood very well, but there is some doubt that the materials will deposit enough toxic material to be effective for long periods of time. Some of the treating materials are inflammable and in our opinion their use adds a dangerous fire hazard. Moreover, the least carelessness in application would leave an untreated area.

Recommendations for Connecticut.—We feel that the years of experience of Dr. Snyder are to be relied upon rather than the statements of chemical control companies advocating methods as yet unproved by long periods of successful use. We recommend that the main reliance be based on structural methods to exclude termites from buildings. Included in these methods are: keeping the wood from contract with the ground, the use of adequately treated lumber, the use of impenetrable concrete or masonry and, for the most complete protection, the use of a metal termite shield. We rely on Dr. Snyder's published statement that no properly installed metal termite shield has ever failed to keep out termites (*4*). It is our opinion that termites are abundant and destructive enough to justify the use of termite-resistant construction in all permanent new buildings.

Services rendered by the station.—We have to date answered every request for examination of buildings, if the request was accompanied by some evidence of termite infestation. In these cases we have outlined for the owner the structural changes needed to exclude termites. In the case of public and semi-public institutions, we have studied the building con-

struction and the amount of termite damage and have submitted definite and detailed suggestions for termite control. We also have spent much time with architects, contractors and building inspectors, for the purpose of acquainting them with the principles of termite control. We hope to see termite control provisions included in building codes, and are working toward that end.

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GRYLLUS DOMESTICUS L. AND CITY DUMPS

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The house cricket *Gryllus domesticus* L., considered an introduced European insect, is now very well distributed throughout the United States east of the Rocky mountains. The literature is very meager and uninforming for the most part, and Hood's statement in 1927(*3*) that it is "not a common insect in the experience of most entomologists" is still quite true. Hood, in summarizing facts regarding its distribution, lists, with the aid of A. N. Caudell of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, 22 states east of the Rockies from which it had been reported up to that time. With the addition now, from the files of the Insect Pest Survey of the Bureau of Entomology and Plant Quarantine, of the states of Maine (H. B. Peirson, Aug. 26, 1934), New Hampshire (P. R. Lowry, Feb. 1931), Rhode Island (A. E. Stene, Aug. 18, 1925), Virginia (E. A. Back, July 1934), Mississippi (R. H. Harned, Feb. 23, 1931), and Wisconsin (E. L. Chambers, Sept. 26, 1934) to its known habitat, we find it authentically recorded from all states east of the Mississippi river except Vermont, Delaware, West Virginia, Wisconsin, South Carolina and Florida. West of the Mississippi river it has been recorded from Minnesota, Nebraska, Oklahoma, Missouri, Texas and Louisiana. It is hoped that entomologists will make an effort to learn the identity of crickets causing household injury. Too many of our notes are not specific as to species. Perhaps *Gryllus assimilis* Fab. is receiving too much credit, as it is often found in houses.

The purpose of this article is not to discuss the distribution of the house cricket but to call attention to the need for more information con-

cerning the relation that exists between it as a household pest and as a breeder in city dumps where the usual run of refuse is deposited during the period an area is being filled in.

In every case followed by the writer during the past 15 years, inquiry has brought out the fact that wherever the house cricket has become a serious house pest, the infested houses are situated near an active city dump. In table 1 are recorded the places and dates of serious house infestations known to have been the result of migration of *domesticus* from city dumps. It will be noted that these occured in 35 cities or towns between 1921 and 1935. A casual study of these outbreaks indicates that *domesticus* is more of an outdoor than a household creature, at least under the average conditions in America.

Table 1.—House infestations by *Gryllus domesticus* known to have been caused by migrations from city refuse dumps.

Year	Place	Date of Injury
1921	Baltimore, Md.	July 14
1923	Brooklawn, N. J.	July 30
1923	Baltimore, Md.	Sept.
1924	Brooklawn, N. J.	Apr. 11
1924	Clifton, N. J.	Sept. 24
1925	Joliet, Ill.	Aug. 18
1926	Baltimore, Md.	July 24
1927	Rochester, N. Y.	Oct.
1929	Kenilworth, N. J.	
1930	Kenilworth, N. J.	
1930	Methuen, Mass.	July 28
1930	Port Washington, N. Y.	July 21
1931	Fall River, Mass.	July 24
1931	Port Washington, N. Y.	June 3
1931	Norwood, Ohio	June 24
1931	Oyster Bay, N. Y.	Aug. 13
1931	Kenilworth, N. J.	July 29
1931	Columbus, Ohio	Aug. 24
1931	Washington (N.W.), D. C.	Dec. 12
1931	Lynn, Mass.	July 27
1931	New Albany, Ind.	Oct. 3
1931	Danvers Mass.	Aug.
1932	Alexandria, Va.	Aug.
1932	Louisville, Ky.	Aug. 29
1932	Washington, (N.E.), D.C.	Sept.-Oct.
1933	West Lynn, Mass.	Sept. 12
1933	Lawrence, Mass.	Sept. 29
1933	Bridgeport, Conn.	Sept. 20
1933	Cleveland, Ohio	June 18
1933	Harrison, Ohio	Sept. 19
1934	Clarendon, Va.	July
1934	Washington, D. C.	Aug.
1934	Biddeford, Me.	Aug. 6
1934	Malden, Mass.	Sept. 25
1934	Throgg's Neck, N. Y.	Sept. 22
1934	Niles, Mich.	Aug.
1934	Milwaukee, Wis.	Sept. 26
1934	Raritan, N. J.	
1934	Little Falls, N. J.	
1934	Harrison, Ohio	Aug. 18
1935	Washington (N.E.), D.C.	May-Oct.
1935	Clarendon, Va.	May-Oct.
1935	Lyon Park, Va.	Oct.
1935	Niles, Mich.	Aug. 3
1935	Lyons, N. Y.	
1935	Utica, N. Y.	
1935	Auburn, N. Y.	
1935	Little Falls, N. J.	
1935	Jersey City, N. J.	Nov. 13

In all outbreaks of *domesticus* investigated by the writer, the conditions have been about the same. Perhaps the most severe outbreak known to the writer was investigated by him on July 24, 1926, when an extensive waste-paper dump in Baltimore was visited at the request of the Baltimore Department of Public Works. No crickets were in evidence throughout the day except as they were exposed during a careful search in the rubbish, but upon the approach of dusk hordes in all stages of growth began emerging from the debris on the dumps and swarmed upon tree trunks and over the ground between the dump and the nearest dwellings, a distance of several hundred feet. The winged forms flew readily, particularly after the city lights were turned on, and telephone and electric light poles along the street became covered with crickets. Crickets crawled in countless numbers up the sides of the houses, seemingly looking for openings through which to enter. They entered the second and third story windows, and even the skylights on the roofs. Scarcely an article of furniture or other object could be moved anywhere in the house without uncovering one to a dozen crickets. Crickets got into the food on the tables, dropped from the ceilings, were found in the beds, and

flew onto the residents as they sat on porches or in the rooms, and their chirping was incessant, loud, and distracting. Owners sat with fly swatters or brooms in hand. At one house the housewife displayed several dustpanfuls of dead crickets swept from her floors as a result of her warfare during the previous evening. Garments of all sorts, but especially thin fabrics, were badly eaten. It is difficult to express the exasperation of occupants of houses subject to cricket invasion.

A few statements from correspondence received in the Bureau of Entomology may serve a purpose. From Baltimore in 1921 a correspondent wrote that householders were being driven to desperation and had resorted to fly swatters but that in spite of this crickets entered the houses, dropped from ceilings at night onto the beds, and were very destructive to wearing apparel, especially silks and woolens. In 1924, a representative of the Brooklawn Community Association in New Jersey wrote that the crickets were noticed first during the summer of 1923, when they became quite a nuisance, that early in the fall the city dump from which they seemed to be emerging was fired but that crickets were again on the increase and were destroying clothing, particularly that made of silk or wool. A resident of New Albany, Ind., wrote in October 1931 that crickets had appeared in dwellings since a city dump had been located close by. A writer from Oyster Bay, N. Y., wrote in August 1931 that his house was entirely infested with crickets coming from the town dump located in his neighbor's backyard. From Kenilworth, N. J., on July 29, 1931, a correspondent wrote that the inside of his house was literally overrun with crickets; that on the outside they climbed up the sides of the house looking for some place through which to enter, even going as high as the roof; that the crickets had only been coming in the last three years, or since a dump had been placed near the house. Another correspondent wrote that "in the house they get into the clothes hamper and eat towels, stockings, etc. In the closets on the street floor they have eaten sweaters and coats—not small holes like moths, but big holes as large as a dime." From Bridgeport, Conn., a person states that his house, built about two years, located near a public dump, has been overrun by crickets for about one year and that the city health department attempted to control the cricket plague but failed. From Cleveland, Ohio, another householder wrote that "the crickets are entering the house by the hundreds; they are coming from a dump across the street which is being filled in by the city." A lady wrote from Steubenville, Ohio "a silk dress of mine has been completely destroyed—which by the way, was on a rack in my wardrobe. I cannot let socks, silk underwear or woolen material lie around for a moment." A man, also a resident of Steubenville, wrote during July, 1932, the crickets "have eaten and destroyed one good velvet rug . . . lately they have chewed holes in a woolen suit." From Throgg's Neck, Bronx, N. Y., a man wrote under date of September 22, 1934, "A considerable area in the residential district of the Bronx which has been settled during the past few years is afflicted with an epidemic of crickets worse than the locusts of Egypt. Probably the epidemic has been caused by the filling in of streets with garbage and refuse. Now, with the approach of cold weather, swarms of

these crickets are infesting the residences. Great bunches of crickets can be seen in corners of rooms, on walls, ceilings and in cellars. The situation is desperate and rapidly becoming worse. Beds are full of crickets and people can't sleep. There are crickets on the table with every meal. In clothing and automobiles they are being distributed to other sections." During November, 1935, a correspondent wrote from Jersey City, N. J., "they eat big holes in our clothes and have not stopped at that but have eaten silk, woolen and cotton drapes as well." From Niles, Mich., a correspondent wrote on August 3, 1935, that in the summer of 1934 he first had trouble with crickets coming from a ravine, located close to his hotel and restaurant, that was being filled with city rubbish. He stated that the crickets did not bother during the day, but that after the lights were turned on in the evening they entered his establishment in swarms and interfered with business.

Judging from conditions existing in the environs of greater Washington, D. C., including city dumps in the northeast section of the city and across the Potomac river in Clarendon, Va., crickets winter over in the dumps themselves as well as in and about houses, sheds, garages, etc., close by. One man claimed that crickets were annoying in his cellar during the entire winter following an outbreak during the summer of 1934. Examinations at intervals from early in May to November 9, 1935, showed crickets in all stages of development present in the refuse of the dumps, indicating that the crickets do not necessarily leave the dumps merely to seek hibernating quarters in houses. It has been suggested that crickets migrate from areas being filled in with refuse mainly to seek the shelter of houses, but the writer doubts this. It would seem that migrations, which occur in largest numbers during the July to October period, are more the result of overpopulation and in some instances are due to scarcity of food.

Once well established in a dump, crickets seem to persist so long as the dump remains active or until it has been covered with ashes or soil. In some instances in Virginia the complaints against crickets during the summer of 1934 became so persistent that an active dump was discontinued and was covered with soil, with the result that house owners surrounding the area claimed not to be troubled during 1935. Another dump causing much trouble as a source of crickets in 1934 was partially covered during the winter of 1934–35 and the spring of 1935, with the result that the cricket problem was materially lessened. It would seem that the cricket problem will normally solve itself with the completion of the fill and its covering with ashes or soil.

House owners, however, are not willing to wait for the normal closing of city dumps. Cities or towns maintaining these dumps are directly responsible for the application of controls to suppress a condition they have created. They need the assistance of the entomologist and more first-hand experience is needed. The problem is not new to entomologists, for similar migrations from dumps have been reported by Galli-Valerio (*2*) and Faes (*1*) in Switzerland and by Kemper (*4*) in Germany during 1929–1931. A separation of garbage into various classes is not an answer to the problem. The writer has seen heavy infestations in all sorts of

dumps, some of the worst cases being in large city dumps where only papers were thrown. Calcium cyanide dust, blown into dumps, waste oil and a 25–30 per cent solution of calcium chloride sprayed over the surfaces, fire, and poisoned baits have been used in the United States and Europe, with no very satisfactory records of results made available. The Baltimore Public Works Department claimed to have suppressed a cricket outbreak by pouring 300 gallons of heavy oil over the rubbish, which was then burned. Probably poisoned baits will prove the most generally satisfactory and safe control. Among baits already used by entomologists for cricket and grasshopper control are the following:

(1) Five pounds of bran, one-fourth pound of sodium fluosilicate, 1 pint of cane molasses, one-fourth gallon of water. Said to be sufficient for one-fourth of an acre.

(2) One hundred pounds of wheat bran, 2 pounds of sodium arsenite, $3\frac{1}{2}$ gallons of water, 1 gallon of very strong molasses. Mix water, molasses, and arsenite together, then add to the bran. To make more attractive, add beef extract.

(3) Fifty pounds of wheat bran, 1 pound of Paris green or white arsenic, 2 gallons of cheap molasses, 3 to 4 gallons of water. Add 6 finely chopped oranges or lemons to the mixture.

For the destruction of crickets once they are within the house, liberal dusting with pyrethrum powder, sodium fluoride or sodium fluosilicate has proved effective. Poisoned baits and fumigation are also effective where practical.

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EUROPEAN CORN BORER ON THE EASTERN SHORE OF VIRGINIA

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The European corn borer, *Pyrausta nubilalis* Hubner, was traced to the eastern shore of Virginia by the finding of two borers by federal inspectors in lima beans which had been shipped from Temperanceville, Va., in October 1931 to a commission house in New York City. Federal scouts were immediately sent into this area and although they scouted all of Accomac and part of Northampton county, only one borer was found. This area was scouted again in the fall of 1932 and the finding of four additional borers, one in Atlantic, two in Lee, and one in Metomkin districts of Accomac county was reported.

This would indicate that the European corn borer was still very scarce and difficult to find in 1932. As far as known, no scouting was done in 1933 and no data are available as to the spread and increase of the borer for that year. A survey of fifty-two corn fields in August and September of 1934 revealed that the European corn borer had spread over practically all of the eastern shore of Virginia from Eastville to the Maryland line. According to our figures, the infestation varied from less than one per cent to fifty-eight per cent of the stalks, with the infestation in the majority of the corn fields averaging less than ten per cent.

In November 1934, one hundred European corn borers were collected, permitted to crawl into corrugated cardboard strips, and placed in an outdoor screen cage in which had been placed pieces of cornstalks, for hibernation studies at Onley, Va. No pupation had occurred by April 22, 1935, but nearly 50 per cent of the borers had pupated by April 29. Moths began emerging on May 4 and were laying eggs by May 15, which were hatching on May 27. Field observations indicated that pupation and emergence occurred as early, or earlier, in the field as in the cages. Larvae hatching on June 6 pupated on July 3, a total of 27 days. Our earliest recorded emergence of second generation moths occurred on June 30, from pupae collected in Irish potato vines on June 26.

A survey made in cooperation with Mr. Arlo M. Vance of the United States Bureau of Entomology and Plant Quarantine, July 10 to 12, revealed that the potato plant is one of the principal foods for the borers of the first generation. This is probably due to the scarcity of corn plants available for oviposition at the time the first generation moths are in flight. On July 10 third, fourth, fifth and sixth-instar larvae, pupae, and emerged pupal cases were found in potato vines. There were practically no large larvae, pupae or emerged pupal cases in field corn at this time, but moths, eggs and newly hatched larvae were quite common in some fields, as many as 22 egg masses being found on the 30 plants examined in one field. When the second generation of moths appeared so early it seemed that there must be at least a partial third generation each year. If so, pupation should begin about the fifth of August and emergence of a third generation of moths and egg-laying should follow from the middle to the latter part of the month.

This is exactly what happened, as large numbers of pupae were present in field corn on August 15 and pupae collected on this date began emerging on August 17 and continued to emerge until August 26. On August 27 and 28 there were a large number of empty pupal cases in the older plantings of corn and there were large numbers of moths, eggs and newly hatched larvae in the later plantings, as many as 30 egg masses being found on the 30 plants examined in one field. From these observations it appears that there is at least a partial third generation of the European corn borer on the eastern shore of Virginia each year. This would probably help to account for the fact that this insect has been able to increase from a very light and restricted infestation in 1931 and 1932 to the general and widespread infestation of 1934.

The European corn borer has multiplied greatly again this year, several fields having over 80 per cent of the stalks infested and one field

was found with 96 per cent of the stalks infested. Based on the dissection of ten stalks, this field had an average of over ten borers per stalk, the population varying from two to 28 borers per plant.

In order to secure information on the relation of planting date to the abundance of the European corn borer, plantings of corn were made May 14 and June 1, 10 and 27, 1935. The results of this experiment are given in table 1. Four lots of 25 stalks were examined on October 9 for each planting date and the first five infested stalks in each lot were dissected to determine the borer population. It will be noted from an examination of this table that there was not much difference between the percentage of stalks infested for the different planting dates. However, there was a decided difference in the number of borers per stalk between the corn planted on May 14 and June 27 as compared with the corn planted on June 1 and 10. When this data was analyzed statistically by the methods described by Fisher & Wishart,[1] the difference was found to be significant.

Table 1.—The influence of date of planting on the abundance of the European corn borer at Onley, Va., in 1935.

Planting Date	Per Cent of Stalks		Borers per 20 Infested Stalks		
	Infested	Broken	Pupal Cases	Larvae	Average per Stalk[2]
May 14	88	26	10	48	2.9
June 1	90	26	6	94	5
June 10	93	37	0	117	5.85
June 27	81	30	0	45	2.25

It is realized that the European corn borer may react differently under varied seasonal conditions, and that this experiment will have to be carried on over a period of years before any general recommendations can be given as to the best planting date for corn to avoid borer injury on the eastern shore of Virginia. However, this year corn planted on May 14 had next to the least number of borers per stalk and produced the best grade of corn. The corn planted on June 27 failed to produce a satisfactory crop this year.

The percentage of infested stalks for a given planting increased very rapidly this year from the latter part of August to the first of October. Corn planted on May 14 at Onley, Va., showed an infestation of 20.5 per cent on August 28, 37.7 per cent on September 12, and 88 per cent on October 9. The population increased from an average of 1.89 borers per infested stalk on September 12 to 2.95 borers per infested stalk on October 9.

If the European corn borer continues to multiply as rapidly in the future as it has in the past two years, it will soon be very destructive to corn and probably to other crops on the eastern shore of Virginia. Other parts of eastern Virginia were scouted rather thoroughly (largely by Mr. Willey and his associates) this fall, but no European corn borers were found.

[1] **Fisher, R. A.** and J. Wishart. The arrangement of field experiments and the statistical reduction of the results. Imperial Bur. of Soil Sci., Tech Comm. No. 10. 1930.

[2] A difference of more than 1.85 may be considered significant.

EXPERIMENTS FOR THE CONTROL OF LARVAE OF *HELIOTHIS OBSOLETA* FABR. ON WESTERN LONG ISLAND DURING 1935[1]

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During recent years the corn ear worm *Heliothis obsoleta* Fabr. has become a serious pest of sweet corn on western Long Island. Although the problem of controlling this insect has been studied since 1931 by the New York State Agricultural Experiment Station, the present paper is confined to a presentation of two experiments conducted as a part of the work of the season of 1935. Most of the treatments mentioned in this paper are probably impractical for use in areas growing field corn or sweet corn for canneries. It was felt, however, that such treatments were worthy of investigation on western Long Island, where much sweet corn is grown for table use.

COMPARATIVE FIELD TEST OF CERTAIN MECHANICAL AND INSECTICIDAL TREATMENTS AGAINST THE CORN EAR WORM

This experiment was conducted near Roslyn, N. Y., on sweet corn of the variety Bantam Evergreen planted June 27, 1935. The period of the treatments extended from August 28 to September 12, 1935. The corn was harvested in two pickings, the first extending from September 17 to 19 and the second from September 24 to 26, 1935. The extended periods of treatment and harvest were made necessary by the uneven rates of development of the corn plants as a result of a period of dry weather during the early summer. The experimental field was laid out in six blocks, each of which contained ten treated plots and one untreated plot arranged at random. Each individual plot consisted of four rows of corn twenty feet long. The plot numbers and their respective treatments were as follows:

1. Untreated
2. Screen wire ear-protectors, fig. 1.
3. Perforated Cellophane bags
4. Plain Cellophane bags
5. Glassine grape bags, fig. 2.
6. Plain paper bags, fig. 3.
7. Clipped husk tips, fig. 4.
8. Lead arsenate 25%, sulfur 25%, flour 50% dusted on silks.
9. *Dutox* (barium fluosilicate) 25%, flour 75%, dusted on silks.
10. *Syncrolite* (synthetic cryolite) 25%, flour 75%, dusted on silks.
11. *Kryocide* (natural cryolite) 25%, flour 75%, dusted on silks.

[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 112, November 25, 1935.

At the beginning of the treatments on August 28, 1935, it was noted that 34.8 per cent of the plants in the untreated rows were in silk. At this time 90.7 per cent of 140 silked ears examined were infested with eggs and young larvae of the corn ear worm.

It was necessary to go through the plots five times, at intervals averaging three days, before all ears were treated. With the exception of the

Figs. 1–5.—Types of experimental treatment against the corn ear worm. Fig. 1.—Screen-wire ear protectors. Fig. 2.—Glassine grape bag. Fig. 3.—Kraft nail bags. Fig. 4.—Clipped husk tip. Fig. 5.—Cloth house used to exclude moths.

glassine grape bags, which were provided with an attached fastening string, all mechanical coverings were fastened closely about the ears with heavy rubber bands. It was originally intended to apply the screen wire protectors and the perforated Cellophane bags to the ears before the silks appeared, in an attempt to secure pollination without the accompanying corn ear worm infestation. It was found in preliminary trials prior to this experiment that pollination was not always satisfactory in ears so covered. In this experiment the ears in plots 2 and 3 were covered shortly after the silks appeared. In most cases it was found that pollination was satisfactory. The ear coverings in plots 4, 5 and 6 were applied

after the silks had begun to wither, indicating the completion of pollination. By this time most ears were infested with eggs and young larvae, making it necessary to disinfest all ears by clipping off the silks and husk tips with sheep shears. As a precaution the ears in plots 2 and 3 also received this treatment before covering.

The screen wire ear-protectors were conical in shape and specifically designed for these experiments. Brass screening, of as fine a mesh as could be conveniently formed, was used. The base of each protector was designed to expand with the developing corn ear. The cellophane bags were made of a laquered, water-resistant grade of that material supplied

Table 1.—1935 harvest data, mechanical and insecticidal field control experiment.

Treatments	Plot Numbers 1 Untreated	2 Screen Wire Protectors	3 Perforated Cellophane Bags	4 Plain Cellophane Bags	5 Glassine Grape Bags	6 Plain Paper Bags	7 Clipped Husk Tips	8 Lead Arsenate Dust	9 *Dutox* Dust	10 *Syncrolite* Dust	11 *Kryocide* Dust
Block A											
No. Ears	33	51	48	44	42	47	36	32	30	44	34
% Infested	93.9	52.9	62.5	47.7	52.4	36.1	44.4	50	73.3	61.4	55.9
% Unfit	42.4	23.5	33.3	11.4	14.3	8.5	16.6	9.4	43.3	27.3	29.4
Block B											
No. Ears	35	33	33	37	31	41	31	24	27	28	30
% Infested	80	45.4	69.7	43.2	48.4	56.1	48.4	58.3	74.1	67.8	66.6
% Unfit	34.3	15.1	33.3	13.5	29	21.9	19.3	25	37	32.1	20
Block C											
No. Ears	29	34	20	40	37	32	18	22	18	27	16
% Infested	100	26.5	65	35	37.8	18.7	61.1	68.2	50	51.8	50
% Unfit	24.1	11.8	5	2.5	10.8	6.2	16.6	22.7	16.6	18.5	12.5
Block D											
No. Ears	38	32	38	24	32	25	47	23	31	17	22
% Infested	94.7	40.6	84.2	37.5	53.1	52	51	69.6	58	76.5	63.6
% Unfit	39.5	9.4	26.3	16.6	21.9	16	2.1	34.8	41.9	41.2	13.6
Block E											
No. Ears	36	41	43	33	36	37	54	32	36	34	33
% Infested	94.4	65.8	62.8	69.7	52.8	32.4	57.4	87.5	80.5	91.2	69.7
% Unfit	55.5	31.7	30.2	39.4	30.8	13.5	11.1	50	33.3	41.2	30.3
Block F											
No. Ears	44	44	49	36	40	26	27	38	39	27	33
% Infested	93.2	50	87.8	50	35	46.1	53.7	71	56.4	70.4	75.7
% Unfit	49.1	15.9	28.6	11.1	15	15.4	11.1	21	38.5	29.6	33.3
Total Ears	215	235	231	214	218	208	213	171	181	177	168
% of Total Infested	92.6	48.1	72.7	47.2	46.3	39.9	52.1	67.8	68	69.5	64.9
% of Total Unfit for Sale	40	18.7	28.1	14.9	19.7	13.4	11.7	26.9	36.4	31.1	25

through the courtesy of the Du Pont Cellophane Company. The holes in the perforated Cellophane bags were approximately three-fourths of a millimeter in diameter. The plain paper bags were flat-bottomed, three-pound nail bags of the type used by corn breeders. In the number 7 plots the silks and husk tips were clipped off when the ears were freshly silked. Pollination was usually not complete at the time of clipping but it was found that the silks continued to grow outward and that successful pollination finally occurred. Each time the plots were visted for the purpose of clipping the newly silked ears the ears previously clipped were examined and re-clipped whenever re-infestations were found. All insecticide treatments were applied to the ears in silk by means of a bellows type "California Beauty" knapsack duster. All ears in silk were dusted at each application.

At the time of harvest the ears were graded for ear worm injury ac-

cording to four degrees of infestation: silk injury, light tip injury, severe tip injury and butt injury. Ears showing injuries of the last two types were considered unfit for sale. Approximately ten per cent of the injury found at harvest was caused by larvae of *Laphygma frugiperda* S. & A., the fall army worm. The ear injury caused by this insect was found to be practically identical with that caused by the corn ear worm. It was not found practical in this experiment to differentiate between the ear infestations of the two species.[2]

In table 1 the proportions of infested and unsalable ears found in the different plots are indicated. The figures shown were obtained at the time of harvest.

Although complete control of the corn ear worm was not obtained in this experiment, it will be noted that most treatments significantly reduced the amounts of infestation and severe injury. With the exception of the perforated Cellophane coverings, the mechanical treatments gave more favorable results than any of the insecticidal treatments used. It should be noted, however, that a total of five applications of each insecticide were made at intervals of as near three days as weather permitted. Experiments by Ditman & Cory (1931)[3] showed that the most effective insecticidal control was obtained when applications were made daily or every other day.

Our experiments showed that in the clipped but uncovered ears most of the larvae found at harvest were small and resulted from re-infestations subsequent to the final clipping treatment. This condition is reflected in the relatively small number of severely injured ears found in the clipped plots. It was found, under field conditions, that approximately 700 ears of corn could be clipped and disinfested by one man in an hour. The principal objections to clipping the husk tips, when the ears remain uncovered, were found to be (1) the danger of exposing the ear tip when more than two treatments are made, and (2) the ease with which migrating larvae could enter the clipped ears. The glassine grape bags became brittle under outdoor conditions and frequently ruptured, whereas the other coverings usually remained intact. Plain paper bags, the cheapest coverings used, appeared to be as satisfactory as any of the other covering materials employed. It is felt that the failure of the perforated cellophane bags to remain as uninfested as the other mechanical coverings may have been at least partly due to the ability of the newly hatched larvae to pass through the perforated openings.

Sweet Corn Grown Within a Moth-tight Enclosure

For this experiment a cloth-covered moth-tight enclosure $33' \times 66' \times 9'$ was erected at Roslyn, N. Y., during May 1935, fig. 5. The covering material was of the grade known by florists as "aster cloth" and was similar, except for more reenforcements, to the cloth used to cover tobacco plants. The "cloth house" was erected according to instructions pro-

[2] The proportion of fall army worms increased toward the end of the season, until on October 10, 1935, during an infestation count made as a part of another experiment, 31.7 per cent of a total of 371 larvae taken from 200 untreated ears proved to be *Laphygma frugiperda*.

[3] Maryland Ag. Exp. Sta. Bul. 328.

vided by the textile manufacturer. Within the enclosure four plantings of sweet corn were made during May and June 1935. The varieties used and the dates of planting are indicated in table 2. For purposes of comparison additional plantings of corn, under otherwise identical conditions, were made outside the enclosure.

During the period of development of the corn plants it was noticed that the plants within the enclosure appeared taller and more slender than those plants outside. At the time of harvest the height of each corn plant was measured and the figures obtained are shown in table 2. It is believed that the difference in height was caused by the lower light intensity which prevailed within the enclosure.

It was noticed that there was no significant difference in time of maturity between the corn plants under the two situations. Eating tests

Table 2.—Summary of 1935 harvest data, "cloth house" experiment.

Variety of Corn	Date of Planting	Location in Relation to Cloth House	Total Number of Plants	Average Height of Plants (in.)[4]	Average No. of Ears per Plant	Per Cent of Ears Infested by Corn Ear Worm
Spancross 39	May 9	inside	273	71.7± .32	1.07	0
	May 9	outside	82	50.8± .43	1.54	3.6
Whitecross 6–2	June 2	inside	221	71.3± .32	.67	0
	June 2	outside	97	58.1± .39	.83	7
Whitecross 6–39	June 10	inside	228	78.3± .54	.78	.04
	June 10	outside	87	62.5± .46	1.01	63
Golden Cross Bantam	June 20	inside	185	70.9± .35	.92	1.1
	June 20	outside	91	61 ± .47	.83	75

showed no apparent differences in quality, apart from insect infestations, between the corn ears grown under cloth and those grown outside. At the time of harvest the number of marketable ears per plant was noted. This data is summarized in table 2.

The ground used had not been planted to corn for at least five years previous to the time of this experiment, nor was corn grown nearer than a distance of 400 yards during the season of 1935. This may account for the low infestation found outside the enclosure at the times when the first two plantings of corn were harvested. The slight infestations found in the last two plantings within the enclosure were caused by corn ear worm larvae of approximately the third instar. It was believed that because of their small size these larvae entered through the meshes of the cloth from the outside.[5]

Although in this experiment the corn ears were successfully protected from the attacks of the corn ear worm, the cost of the cloth enclosure as used in 1935 was too expensive for practical use. It is hoped that further work in this direction will reveal a means of obtaining this type of control on a more economical basis.

[4] Height measured in inches to lowest tassel branch.

[5] A small number of other lepidopterous larvae, mostly Arctiids, were found causing slight injury to corn silks within the enclosure. It is believed that these larvae emerged from pupae already in the ground at the time the area was covered with cloth. During the entire experiment a total of four larvae of the European corn borer *Pyrausta nubilalis* Hubner were found within the enclosure, as contrasted with an infestation in which over two-thirds of the ears outside were infested by larvae of the first brood of this species during early August.

NOTES ON THE EUROPEAN PINE SHOOT MOTH

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In 1933 the authors (Friend & Hicock, 1933) reported on the status of the European pine shoot moth *Rhyacionia buoliana* Schiff., in Connecticut at that time. Our investigations showed that there were 149 infested red pine plantations aggregating an area of about 3000 acres, and that the insect was more abundant in the southwestern part of the state (Fairfield county) than elsewhere. Not all the plantations over the entire state had been examined, so that this figure simply represents what had been found and not what was actually present. At that time it appeared that the outbreak might be only beginning and not at a peak. Since then the picture has changed somewhat due to the control operations carried on throughout the state and the severe winter of 1933–1934.

Control operations in red pine forest plantations, and to a limited extent in ornamental plantings, have been undertaken since the spring of 1933 by the personnel of the Civilian Conservation Corps and by men employed under the CWA and the FERA. The state forester, Mr. A. F. Hawes, has been administrative officer of all this work, and the supervision has been exercised by the departments of entomology and forestry of the agricultural experiment station. The control work by men employed under the federal relief agencies mentioned above has been of temporary duration, but shoot moth control is a regular part of the work of the Civilian Conservation Corps of this state. All of this work has, of course, been subject to the approval of the Division of Forest Insects of the federal Bureau of Entomology.

The object of the control measures has been either to completely eliminate the insect from young plantations or so reduce the insect population in the area that a local outbreak could not occur before the stand closed. Our observations on the relations of this insect to red pine stands indicate that outbreaks in a plantation take three to five years to develop to an injurious extent, after the introduction of the insect, under favorable conditions, and that outbreaks do not usually occur after the stand has closed.

Up to the spring of 1935 very little control work had been done in Fairfield county because it was deemed advisable to concentrate on the more lightly infested parts of the state. This should be borne in mind in comparing the relative abundance of the insect in 1934 and 1935. Also it appears that the severe winter of 1933–34 affected the population less in Fairfield county and eastward along the shore of Long Island Sound than elsewhere in the state. The relations of winter temperature to shoot moth abundance have been discussed by A. S. West, Jr., whose paper is now in press.

Our records of the status of the infestation in 1934 and 1935 throughout the state show that there has been a noticeable decrease in the abundance of the insect. The condition of the infestation in 1934 is based

on the abundance of injured buds on the trees, whether or not these buds contained living larvae. The larval mortality during the previous winter had been high, so that any reduction in shoot moth population can by no means be entirely attributed to control work. That the control operations have been effective, however, is indicated by the condition of some red pine stands near New Haven which have been closely watched by the authors. In the following table are included only those plantations which have been examined by the control crews and where control operations have been carried out if necessary. An attempt was made to visit every plantation in the area concerned, with the exception of Fairfield county as noted above, so that the figures are comparable. Practically all of the plantations are of red pine, either pure or mixed with other conifers, the few exceptions being where Scotch or Austrian pine was the host tree. The difference between the number of plantations in 1934 and 1935, aside from Fairfield county, is not great and does not affect the comparative value of the data.

Table 1.—Pine shoot moth infestations in Connecticut.

County	Severity of Infestation (number of plantations)									
	1934					1935				
	None	*Light*	*Medium*	*Heavy*	*Total*	*None*	*Light*	*Medium*	*Heavy*	*Total*
Fairfield	2	6	2	1	11	15	78	33	26	152
New Haven	9	20	10	7	46	16	35	7	1	59
Middlesex	9	30	5	3	47	14	30	1		45
New London	33	34	7	3	77	27	33	9	2	71
Litchfield	57	164	36	26	283	134	132	12		278
Hartford	20	72	23	9	124	80	38	1		119
Tolland	17	64	8		89	74	7	1		82
Windham	50	20			70	65	7	1		73
Total	197	410	91	49	747	425	360	65	29	879

Total acres in 1935, 10,221

If the figures for Fairfield county, where only 11 plantations were concerned in 1934 as compared to 152 in 1935, are excluded, 736 plantations were involved in control operations in 1934 and 727 in 1935. In 1934, 26 per cent of the plantations were uninfested, 55 per cent lightly infested, 12 per cent with a medium infestation, and 7 per cent heavily infested. In 1935, 56 per cent were uninfested, 39 per cent lightly infested, 4 per cent had a medium infestation, and less than one-half of one per cent were heavily infested. The greatest decrease in shoot moth population has occurred in the northern tier of counties (Litchfield, Hartford, Tolland, Windham) where the general infestation has never been severe and where the winters are colder than in the counties bordering Long Island Sound. The figures given in the table were obtained from the reports of the foremen in charge of the control crews, so that the personal factor enters into the estimation of the degree of infestation to a certain extent. In the authors' opinion this factor is not of sufficient importance to affect the general picture, as the work has been closely supervised and the foremen have had experience in forestry or in entomological control operations.

The reason for the decrease in the abundance of this insect is largely due to the very cold weather during the winter of 1933–34 and to the control operations that have been carried out. Although young stands may be protected from injury by the method of control used, that is, the

removal of infested tips, the labor involved is much less and the results much better if the infestation is light. The figures given in the table substantiate this. The abundance of the shoot moth, other things being equal, is correlated with the age of the red pine stands, as reflected in their height, and as the proportion of very young stands in the state decreases, the insect population may be expected to decline even though other environmental conditions are favorable to it.

The work on ornamental plantings has been supplementary to that on forested areas, as the primary aim of control operations has been the protection of forests. Ornamental and forest plantings often are within a short distance of each other, however, and it is by no means always possible to draw a line of distinction between the two. Inasmuch as an effort was made in 1935 to reduce the shoot moth population in Fairfield county, particularly in Greenwich and Stamford, the control crews worked on both types of plantings in this area. The figures given in the above table show that red pine forest plantings in Fairfield county are well infested in general, and the work on ornamental trees shows that this forest infestation may well persist in spite of control operations unless the ornamentals are kept clean. All ornamental trees which are hosts of this insect were included in the control work in the area concerned. There were examined in Greenwich and Stamford 47,744 trees (including those not infested) and 178,274 tips were removed. The extent to which ornamental trees may become infested is indicated by reports, in some cases, of from 50 to 100 injured tips from a single tree not over eight feet in height. Our estimation of the number of injured tips removed in 1935 shows that Fairfield county, with about 14 per cent of the total area of plantations covered and with 70 per cent of the total ornamental trees involved, had 91 per cent of all the injured tips that were found in the entire state. These figures are an approximation but they do represent relative conditions.

During the past season spraying experiments were carried out in a stand of infested red pines 20 to 25 feet in height. Two applications were made, one at about the time the eggs began to hatch (June 22) and the other 10 days later (July 2). The incubation period of the eggs under field conditions is approximately 10 days. The following three mixtures were compared: (1) lead arsenate 1.5 pounds, fish oil 1 pint, water 50 gallons; (2) ground derris root (4 per cent rotenone) 1 pound, powdered skim milk .5 pounds, water 50 gallons;[1] (3) lead arsenate 1.5 pounds, waterproof glue .5 pound, bentonite .5 pound, hydrated lime 1.5 pounds, water 50 gallons. About five gallons of the material were applied per tree. This is a large amount, but the insecticide must reach the junctions of the needle bases with the twigs, the only point of entrance of the first larval instar, and a heavy application is necessary.

The estimation of effectiveness was made by taking a sample of 10 branches from the top of each of three trees and 25 branches at a height of about 10 feet from each of the same three trees and noting the number of injured tips. These samples were taken August 20 and 22, when prac-

[1] In the first application the derris-skim milk was found to have been diluted to 75 gallons instead of 50. This weakens the comparison of results with lead arsenate.

tically all the larvae had entered the buds. The sprayed blocks alternated with those not sprayed and used as checks. The results are given in the following table.

In addition to the difference in the percentage of injured tips between sprayed trees and those not sprayed, there is a consistent but small difference in the number of living larvae per injured tip. Under the conditions of sampling this is of questionable significance. The lead arsenate —fish-oil mixture gave good results. In a previous publication (Friend & West *2*) one of the authors suggested that the recommended three applications of this insecticide might be reduced to two. The results attained with two applications are not so good as those previously attained with three, but spraying conditions were more difficult in the former case. Two applications, correctly timed, should control this insect on ornamental trees. Although a single application of this insecticide

Table 2.—Spraying results, European pine shoot moth.

Insecticide	Injured Tips	Uninjured Tips	Larvae per Injured Tip	Per Cent Tips Injured	Per Cent Control
Derris-skim milk	34	174	.59	16	66
Check	112	127	.74	47	
Lead arsenate-fish oil	17	226	.53	7	88
Check	150	110	.64	58	
L.a.-glue-bent.-lime	38	238	.61	14	78
Check	141	80	.74	64	

has not given the authors good results in past experiments, it is felt that the application has not been properly timed, and further trails will be made. The derris—skim milk mixture might well have given better results had it been properly diluted in the first application.[1] This material, properly used, may well be effective. Glasgow (mimeographed circular) recommended 1.5 pints of a cubé or derris extract containing 5 per cent rotenone plus 2 gallons of miscible pine oil in 100 gallons of water, the application to be made June 25 and July 4 (in New York). In view of recent results with derris, the ground root is probably better than the extract.

The two most common native parasites of the European pine shoot moth in Connecticut are *Calliephialtes comstocki* Cress. and *Hyssopus thymus* Gir. In the spring of 1935 collections of red pine tips from Hamden and Easton indicated that the latter was more common than the former, although neither species was strikingly abundant. At Hamden a collection of 52 tips on May 24, 1935, contained 46 live shoot moth larvae and pupae and six larvae parasitized by *H. thymus*. Adults and eggs of this parasite were observed on this date. A collection of 38 tips at the same locality on June 7 contained 35 live shoot moth larvae and pupae and three larvae parasitized by *H. thymus*. A miscellaneous collection of tips from Easton, June 6, 1935, was examined for parasitized larvae and all those found were held for rearing. Three larvae were parasitized by *Eurytoma tylodermatis* Ashm., two by *C. comstocki*, five by *H. thymus*. From a mass of material from the same locality large numbers of *C. comstocki* emerged, but the proportion of parasitized larvae was not obtained. The only definite data is that from Hamden, which shows a parasitism in the last larval stages of from 8 to 12 per cent by

H. thymus. Up to 19 individuals of this species have been reared from one shoot moth larva.

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Scientific Notes

Correct Name for the Mexican Bean Beetle. The first technical description of the coccinellid beetle commonly known as the Mexican Bean beetle was published by Mulsant in his 1850 work, "Species des Coléoptères Trimères Sécuripalpes." In this work, on pages 812–19, that author described a series of supposed new species in the following order: *Epilachna varipes, E. murina, E. corrupta, E. varivestis, E. modesta* and *E. difficilis.* Two varieties of *E. varivestis, cervina* and *genuina* were also named there.

Subsequent workers in the Coccinellidae have not agreed with Mulsant as to the separation of these forms as species. The first to publish an opinion on the question was G. R Crotch. In his "Revision of the coleopterous family Coccinellidae," the first 160 pages of which were published prior to October 1872, Crotch (p. 62) recognizes but two species in the complex, placing the first four above named as one species under the name of *E. varivestis* Muls. and the last two as another under the name *E. modesta* Muls. In 1931 Korschefsky threw all six together as a single species under the name *E. corrupta* Muls. (Junk-Schenkling, Cat. Coleopt., Pars. 118, p. 58).

Unless it can be shown that the union of the Mulsant species is unsound zoologically, the proper name for our bean beetle is to be selected under Art. 28 of the International Code which states, in effect, that when a species is formed by the union of two or more species of the same date, the name selected by the first reviser from among the two or more names shall be accepted.

Since present evidence points to the correctness of the views of Crotch and Korschefsky as to the identity of *E. varivestis* Muls. and *E. corrupta* Muls. there is no alternative but to adopt the name selected by the first reviser, to wit: *Epilachna varivestis* Muls.

Edward A. Chapin, *U. S. National Museum.* 11-9-35

Toxicity of Dextro and Levo-Alpha-Para-Tolylpyrrolidine to *Aphis rumicis* L.—Previous studies of the toxicity of synthetic heterocyclic nitrogen compounds to insects have been chiefly concerned with optically inactive compounds. The resolution of the racemic compounds into their optical isomers is often difficult and tedious, and the few that have been resolved have not been tested for insecticidal action. Since the naturally occurring organic insecticides are generally optically active, comparisons of the toxicities of synthetic and natural compounds have been based upon different optical forms.

It has recently been shown that *dl*-nicotine, as a contact insecticide, is only about half as toxic to *A. rumicis* as *l*-nicotine.[1] In this instance, then, the dextro form of the compound appears to be of low toxicity, adding little to the toxicity of the *l*-nicotine.

An opportunity has been afforded to study the toxicity of the optical isomers of α-p-tolylpyrrolidine, a compound related to nicotine. The preparation and resolution of these compounds will be published elsewhere.

The spraying technique was one already published.[1] The test insect was the adult wingless *A. rumicis.* Sodium oleate, .25 gram per 100 cc. of solution, was added to the solutions of the compounds as a spreader and emulsifier; controls sprayed each day with the sodium oleate solution produced mortalities ranging from 0 to 27 per cent, the mean being 7.9 per cent. In addition, groups of aphids were sprayed daily with two concentrations of *l*-nicotine base as a check on the uniformity of the aphid population. Each group of insects contained 10 individuals and there were 5 replications for each concentration of a compound.

The spray solutions were prepared from the acid tartrate salts of the bases, the bases being liberated by a calculated amount of standard sodium hydroxide solution, and the requisite amount of sodium oleate was added to each. The concentrations are reported as

[1] **Craig and Richardson,** 1933, Iowa State Coll. Jour. Sci. **7**(4): 477–86.

grams of free base per 100 cc. of solution. Tests showed that the sodium tartrate formed in the *l*-nicotine solutions by the reaction of sodium hydroxide with the tartrate radical had no appreciable effect on the toxicity.

The toxicities of the two isomers and those of *l*-nicotine base and *l*-nicotine acid *d* tartrate (the base being liberated with sodium hydroxide solution) are summarized in the following table. The net percentages of mortality are calculated from the expression, $\frac{(x-y)\,100}{x}$ where x is the percentage of living insects in the control (sodium oleate) group and y the percentage alive in the experimental group.

Compound	Concentration of Base	Net Mortalities *per cent*	
	grams per 100 cc.	Range	Average
l-Nicotine	.02	13–13	13
	.03	32–89	55
	.04	35–89	69
	.05	77–77	77
	.08	89–100	93
l-Nicotine acid *d* tartrate	.02	18–45	32
	.03	29–80	59
	.04	80–100	87
	.06	90–100	94
l-α-p-Tolylpyrrolidine acid *l*-tartrate	.6	0–20	1
	1.2	0–32	11
	1.5	49–80	65
	1.8	80–100	90
	2.4	100–100	100
d-α-p-Tolylpyrrolidine acid *d*-tartrate	.6	0–10	6
	1	8–69	35
	1.2	36–68	51
	1.45	32–100	64
	1.8	36–57	47
	2.4	33–100	58

The dextro and levo isomers of α-p-tolylpyrrolidine represent two types of toxicity. Near the point of 50 per cent net mortality the dextro isomer appears to be as toxic as the levo isomer, but at higher concentrations the mortality values for the levo form are much higher. A rechecking of the higher concentrations of the dextro isomer substantiated the earlier results.

l-Nicotine has frequently been used as a standard of comparison for contact insecticides. It seems however that *l*-nicotine acid *d* tartrate may furnish a more convenient and more uniform standard. The salt is readily prepared by mixing one mole of *l*-nicotine with 2 mols of *d* tartaric acid in 75 per cent ethyl alcohol. It has the formula $(C_4H_6O_6)_2 \cdot C_{10}H_{14}N_2 \cdot 2H_2O$. The compound, when recrystallized two or three times from alcohol and air dried, is nearly 100 per cent pure and keeps for months without change. It is a solid, is convenient to handle and is readily soluble in water. When neutralized with sodium hydroxide (8.04 cc. 1.0 N solution per gram of nicotine salt) the solution is practically identical in toxicity with free *l*-nicotine.

Donald Starr and Charles Richardson, *Iowa State College*. 11-12-35

An Outbreak of the Gooseberry Fruitworm and its Control with Powdered Derris and Cubé Root.—In 1934 and 1935 certain currant plantings in Orange and Ulster counties of New York were severely attacked by the gooseberry fruitworm, *Zophodia grossulariae* Packard. In a few cases the damage was so great that the growers did not pick any of the crop. In other instances only sections of plantings were so injured.

Heretofore control measures recommended against this pest were (1) the use of heavy

dosages of lead arsenate to be applied before the calyces were closed, (2) hand picking of the infested clusters to destroy the worms, and (3) clean cultivation to destroy the pupae. Since there did not seem to be conclusive proof that any of these measures were entirely satisfactory, a series of control experiments was conducted in 1935. Plats were treated with lead and calcium arsenates, natural cyrolite, Kutane (cuprous cyanide), black leaf 40, black leaf 155B (bentonite-nicotine sulfate with zinc oleate), powdered pyrethrum and powdered derris and cubé root.

In sprays the materials were used alone and in combination with stickers and spreaders. They were also applied as dusts when mixed with diluents or carriers. Applications were made either when the blossoms were open, soon after all the calyces had closed or after the first webs were formed by the worms. In certain instances two applications were made. All treatments were replicated three or more times.

The following conclusions may be drawn from the 1935 experiments. Lead arsenate at the rate of 2, 3, 5 and 7 pounds and calcium arsenate used at the rate of 2 and 4 pounds in 100 gallons of water gave some protection, but in no case was the control satisfactory. The 90–10 and 50–50 lime arsenate dusts did not control the worms. All arsenical dusts and sprays, when used in quantities sufficient to reduce the insect damage appreciably, left residues far in excess of what could readily be removed from the fruit at harvest time. Kutane 3 pounds and natural cryolite 3 to 4 pounds in 100 gallons of water gave fair control. In all instances the best results were obtained when two applications were made, the first applied while 60 per cent of the calyces were still open, and the second six to eight days later. The nicotine compounds and powdered pyrethrum used either in sprays or dusts were of little value in controlling this insect in 1935.

Powdered derris and cubé root containing 5 per cent rotenone gave good control when used in sprays. The best results were obtained when two applications were made with either of these materials used at the rate of 2 pounds in 100 gallons of water. The first application was made on May 21 (one day after the calyx spray was begun on McIntosh apples) and a second spray was applied on June 3. Almost as good results were obtained from one application using 4 pounds of derris or cubé in 100 gallons of water. This spray was applied on May 29, just as the worms were beginning to web the clusters together. Derris gave slightly better results than cubé when used in sprays. Dust mixtures containing either derris or cubé root and having .5 per cent rotenone gave good control but were slightly inferior to the sprays. There was no apparent difference in toxicity between derris and cubé when used as dusts in these tests. Both clay and talc proved satisfactory as diluents.

O. H. Hammer, *New York State Agricultural Experiment Station.* 11-25-35

Injection Method for Dispersion of Oil into Tank Mixtures.—The rather wide use of refined oils or oil emulsions with arsenical sprays for control of the codling moth created a need for lowering of the costs of such materials. The use of prepared emulsions in the spray tank with arsenical mixtures is well known. Investigation shows that lead arsenate when used with lime, spreaders, Bordeaux, etc., will partially stabilize finely divided oil particles if moderate agitation is maintained. It has been found that untreated oils or oils containing small amounts of products aiding in their emulsification with water can be dispersed, by a method called "injection," into a spray mixture containing the mentioned stabilizers. A small secondary suction controlled by one valve was attached to the pump suction. After the other materials have been added to the tank the oil is drawn into the mixture through the pump. The pressure and pump action so disperses the oil as to produce about the same oil-particle size as is obtained with a stock emulsion that may be poured into the tank or most of the tank-mix emulsions. The method vastly cheapens the cost of oil combinations adaptable for use in arsenical sprays. It also promises to be useful in the preparation of dormant emulsions suitable for San Jose scale sprays. Dormant oils require a stabilizer in the water before the oil is "injected" into the mixture. Promising stabilizers for making dormant oil sprays containing two gallons of oil per 100 gallons are: 2 pounds soybean flour (5% oil content); or 1 pound casein with sufficient ammonia to dissolve; or 1–1–100 Bordeaux; 8–8–100 Bordeaux; or 8 pounds hydrated lime; 2 pounds trisodium phosphate; or 1 pound sulfonated alcohol; and certain proprietary emulsifiers.

M. D. Farrar and W. P. Flint, *Illinois Natural History Survey.* 12-7-35

Longevity of Adults of Elm Leaf Beetle.—During May 1935 a large number of adults of the elm leaf beetle *Galerucella xanthomelaena* Schrank, were collected as they were leaving hibernation quarters in Woburn, Mass., by R. Wooldridge of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. They were forwarded to the bureau's laboratory at Morristown, N. J., for use in transmission experiments with the Dutch elm disease fungus. Shipments of beetles reaching Morristown between May 21 and May 28 were placed in three-gallon glass jars in a screened insectary. The jars were covered with cloth and the beetles were given fresh elm foliage as needed.

Beetles were removed from the jars from time to time for transmission experiments and it was finally decided to determine how long the remaining adults would live. Feeding injury was noted on the foliage as late as September 20, and 10 adults were alive on October 7. The last two adults died on or about November 11. No record was kept as to the time eggs were first deposited in the jars but numerous clusters were laid as late as the first half of August and two were noted as late as August 27. Eggs laid between August 14 and August 16 hatched normally, the first larvae issuing on August 21.

T. H. Jones, *U. S. D. A., Bureau of Entomology and Plant Quarantine.* 12-15-35

Elm Bark Beetles in New York State.—In 1934 it was decided to scout all of New York state to find out the distribution of the elm bark beetles. This work was carried on during the falls of 1934 and 1935. Elm trees were found growing in every county although scarce in the mountainous sections, where they were found chiefly along the streams. All records are based on adult beetles which were found in the galleries. The localities especially covered were the borders of the state and the vicinities of basket factories where elm logs have been concentrating for many years.

Scolytus multistriatus Marsh, the lesser European elm bark beetle, was found in all or parts of the following counties: Richmond, Kings, Queens, New York, Bronx, Nassau, Suffolk (western fourth), Westchester, Saratoga (Crescent, Clifton Park, Round Lake, Quaker Springs), Rockland, Orange, Sullivan (Wurtsboro), Ulster (east of the mountains), Dutchess, Columbia, Greene (Catskill, Kiskatom), Albany (Albany). The infestation evidently spreads from New York City in all directions but especially up the Hudson valley. Probably the beetles extend north nearly to Saratoga Springs but become scarce above Greene and Columbia counties. The beetles have reached only a short distance on Long Island, mostly due to the fact that most of the elms are planted.

Hylurgopinus rufipes Eich., the native elm bark beetle, was found abundantly wherever elms occur.

Scolytus sulcatus Lec., a bark beetle common in dying apple trees, was found breeding in elm at Pelham Park (New York City), North Petersburg (Rensselaer county) and Albany.

Blackman, M. W. 1934. A revisional study of the genus Scolytus. U. S. D. A. Tech. Bul. **431.** pp. 1–30.

Knull, J. N. 1934. Scouting for elm scolytids. Jour. Econ. Ent. **27**(4):865.

Reynolds, R. V. and Raymond J. Hoyle. 1921. Wood-using industries of New York. N. Y. State Coll. For. Tech. Pub. **14.** p. 80.

Henry Dietrich, *Boyce Thompson Institute.* 12-15-35

***Scolytus sulcatus* Lec. on Apple in New York State.**—This bark beetle became very noticeable in the lower Hudson valley on apple after the hard freeze of 1933–34. It was very common the past summer. It was found breeding as far west as Cicero and Pulaski and as far north as North Petersburg. It was not found in the extensive apple sections of Lake Champlain and western New York although there were many dying apple trees.

Henry Dietrich, *Boyce Thompson Institute.* 12-15-35

Comparative Toxicity of Dust Mixtures Containing Derris and Cubé to the Tobacco Flea Beetle under Cage Conditions.—Since dust mixtures containing derris or cubé root have shown definite promise in controlling the tobacco flea beetle *Epitrix parvula* Fab. on tobacco, it seemed desirable to determine whether there is an appreciable difference in the toxicity of these two materials to the insect. With this objective a series of parallel experiments was conducted under laboratory conditions at Quincy, Fla., during the summer of 1934.

In performing these experiments 75 *Epitrix parvula* adults were confined in an 8-inch lantern-globe cage. Eight one-hundredths of a gram of derris or cubé dust, containing

.05 per cent of rotenone, with a total carbon tetrachloride extract of .2 per cent, was then introduced into the cage through a vertical tube inserted at the base by means of a precision duster. A nearly neutral, denicotinized tobacco dust of fine mesh was used as the diluent. The tops of the cages were covered with rubber cloth during the dusting, but cheesecloth was substituted as soon as the dust cloud had settled. The indicated strengths of dusts were selected for use because preliminary trials revealed that applications of either mixture containing more than .05 per cent of rotenone under the described cage conditions resulted in practically a 100 per cent mortality of the beetles, and that dosages smaller than .08 gram per cage caused excessive variations in results.

Twenty pairs of cages, one in each pair for the derris dust mixture and the other for the cubé dust mixture, with a check cage for each pair, were included in the tests. Therefore a total of 1,500 beetles were subjected to each insecticide.

Records of beetle mortality were taken 24 hours after the application of the dusts, since this period of exposure appeared to be most adaptable for comparative purposes. Superficial observations indicated that the mortality was due primarily to the introduction of the dusts into the alimentary tract while the beetles were cleaning their appendages, such cleaning being stimulated, apparently, by the irritation caused by the dust on their bodies.

A summarization of results, including the probable error involved, revealed an average mortality of 85.1 ± 1.2 per cent, in the cages treated with the derris dust mixture, and of 85.7 ± 1.4 per cent, in the cubé dust series, as compared with a mortality of .5 per cent in the check cages. The results indicate that these particular samples of derris and cubé had no significant difference in toxicity against the tobacco flea beetle under the conditions imposed in these experiments.

F. S. CHAMBERLIN, *U. S. D. A., Bureau of Entomology and Plant Quarantine.* 1-10-36

Disease Checks Bertha Army Worms.—After an apparent absence for the preceding six years, the Bertha army worm *Barathra configurata* Walk. became abundant and particularly destructive to flax in several of the central North Dakota counties in 1935. Flax fields in the infested area examined during the latter part of July showed infestations ranging from only a few worms to upwards of 200 per square yard. In the heavier infestations complete destruction to flax resulted, due to the bolls and leaves having been stripped, while in lighter infestations the percentage of injury was correspondingly less severe. It was then observed that disease was beginning to act as an important natural agency of control. By the first week in August disease had destroyed upwards of 90 per cent of the army worms in fields where their population approximated 100 or more per square yard, but where the worms were fewer in number the percentage mortality from disease was less. Field inspections made in response to reports of army worm prevalence from three of the counties showed that the disease distribution corresponded closely to the distribution of the worms.

Diseased and dead larvae of *Barathra configurata* were submitted to the department of bacteriology for examination for determination of the etiological agent of disease. The visceral contents of the larvae were unusually mucilaginous and strung out from the probing needle. Cultures of an organism were readily obtained which gave the following characteristics:

Thick rods; .8–1 micron wide by 1–1.5 micron long, occurring singly and in pairs; rounded ends; gram-negative. No spores observed.

In all cultural and physiological characteristics the organism agrees very closely with *Klebsiella capsulata* (Sternberg) Bergey et al, described in Bergey's "Manual of Determinative Bacteriology." Stock cultures are being maintained.

Literature describes at least one other instance of infection of caterpillars by members of the tribe Klebsiella. (Diagnosis by Dr. Casper I. Nelson.)

J. A. MUNRO, *Entomologist, North Dakota Agricultural Experiment Station.* 1-10-36

Dinitro-ortho-cyclohexylphenol Offers Promise In Control Of Citrus Red Mite.—In connection with a rather extensive study of the control of the citrus red mite *Paratetranychus citri* McG., during the past two years many materials have been tested. The nature of the problem is such that an effective, inexpensive and otherwise satisfactory material that could be properly applied in the form of dust would be ideal even though several applications might be necessary. Preliminary experiments with dinitro-ortho-cyclohexyl-

phenol applied as dust have shown that this material is highly toxic to those mites contacted including those in the quiescent period prior to molting. An appreciable percentage of eggs are also killed.

This dinitro phenol-compound is soluble in a petroleum oil of 90 to 95 per cent unsulfonatable residue to the extent of about 2½ per cent by weight, while in a petroleum oil of 70–75 per cent usulfonatable residue it is soluble to the extent of about 6 per cent. It is only very slightly soluble in water. When this compound is used in solution in oil its toxicity to the several insects and the mite studied and its safety to the citrus tree are greater than when used without oil.

Oil with this compound in solution has been incorporated with certain of the commonly used diluents for insecticidal dusts such as hydrated lime, talc, bentonite, sulfur and diatomaceous earth. Based on present information, a certain grade of diatomaceous earth appears most promising as a vehicle to carry the oil—dinitro phenol-compound principally because of its light, bulky nature. This type of dust mixture is prepared as follows: an amount of oil (with 5 per cent by weight of the dinitro phenol-compound in solution) equaling 20 per cent of the complete dust mixture is slowly atomized into a special mixing apparatus (in operation) which contains the diatomaceous earth. After 15 minutes of continuous mixing the dust mixture is "fluffed" and is ready for use. This dust mixture contains 1 per cent of the dinitro phenol-compound, and due to the high oil content it possesses excellent adhesive properties. Experimentally it has not only shown considerable promise in the control of the citrus red mite but in preliminary tests has caused a very high percentage of mortality to the following insects on citrus: the green citrus aphid *Aphid spiraecola* Patch, the melon aphid *Aphis gossypii* Glov., crawlers (nymphs) of the black scale *Saissetia oleae* Bern., and the California red scale *Chrysomphalus aurantii* (Mask.).

Limited tests with this dinitro phenol-compound dissolved in oil and applied as spray have given promising results in the control of the citrus red mite and the black scale on citrus, and of the frosted scale *Lecanium pruinosum* Coq. on Persian walnut. Laboratory tests of this compound on larvae of the codling moth *Carpocapsa pomonella* Linn., and of the orange tortrix *Tortrix citrana* Fern., yielded encouraging results. In these instances the indications are that the material acted principally as a stomach toxicant. Apparently its effectiveness is not rapidly decreased upon exposure to atmospheric conditions.

Plant injury (citrus) has been negligible to date even with relatively high dosages.

The cooperation of Dr. C. H. Richardson, Iowa State College, and Mr. L. E. Mills and Dr. E. C. Britton of the Dow Chemical Company, has been especially valuable in this work and is greatly appreciated.

A. Boyce and D. T. Prendergast, *University of California, Citrus Experiment Station.*
1-21-36

Notice

Please examine the membership list (pp. 257-78) carefully and advise me promptly if your name does not appear, is incorrectly spelled, or the address incorrect. It is inevitable that, with the changes in the staff that have recently been made, errors of omission and commission will creep in.

You will shortly receive a statement of your indebtedness to the Association. This statement should have gone out under normal conditions in October, 1935, but had to be delayed until the St. Louis meeting in order to confirm the increase in dues and the subscription price. It is my understanding that many members have forwarded their dues in the old amount and they will therefore find on their statements the added amount necessary to bring their accounts up to date in accordance with the new schedule of payments. Individuals who might have been dropped, under the regulations, at the St. Louis meeting on account of being in arrears in dues have an opportunity at this time to bring their accounts up to date without having their cases considered by the Membership Committee.

Ernest N. Cory, *Secretary*

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RETIREMENT OF E. PORTER FELT

THIS ISSUE of the JOURNAL marks a milestone in both the history of the Association and of its official organ. The most distinctive mark of this milestone is the retirement, at his own earnest request, of Dr. E. Porter Felt as editor.

Dr. Felt held the position of editor from the time of issuance of the first number of volume 1, in February 1908, until the recent annual meeting, a period of twenty-eight years. No other member of the Association has served in an official capacity for so long a time or given so much effort in behalf of the JOURNAL and, therefore, the Association. Only those who are intimately acquainted with the burden of an editorship of a publication as large and comprehensive as the JOURNAL and without plentiful funds can appreciate how much the Association is indebted to Dr. Felt.

The JOURNAL was established upon a solid foundation and the general makeup of the numbers has changed fundamentally but little in the twenty-eight years since its establishment. A glance at the first volume will reveal a publication sponsored at that time by two hundred eleven active and forty-five foreign members, which compares most favorably with the present JOURNAL supported by a membership of nearly twelve hundred. In fact, the necessity of printing a larger number of papers and other material has forced the JOURNAL within recent years to sacrifice some of the more desirable features of earlier volumes. The rising generation is always likely to think that all progress is a gift of their efforts. Earlier entomologists of the Association knew where they were going and built wisely. No one will question the many advances in perspective and technique within recent years in specialized fields of our science but younger members of the Association would do well to take cognizance of their heritage and the foundation upon which they now stand.

The present editor would like to call to the attention of every member of the Association the report of the Advisory Committee at the St. Louis meeting in appreciation of the efforts of the past editor, Dr. E. Porter Felt. This appears in the business proceedings of the meeting. We are delighted, too, that the name of E. Porter Felt will continue to stand as Honorary Editor of the JOURNAL in association with the administrative personnel. Long may it be there.

* * * * * * *

THE FEBRUARY NUMBER

MEMBERS of the Association have experienced before a delayed appearance of the February number of the JOURNAL. Of all the numbers this one is the hardest to get out on time because it carries the proceedings of the annual meeting and is subject to changes occasioned by mandates or recommendations adopted at annual business sessions.

The recommendations approved at the St. Louis meeting and subsequent decisions of the Executive Committee have considerably changed certain policies heretofore followed in the publication of the JOURNAL. These changes, coupled with the election of an entirely new administrative personnel, have presented a favorable opportunity for the initiation of some new features in printing and arrangement. It is obvious, perhaps, that there are many advantages to the Association and to the editor in selecting a printer as close to the editor's residence as possible, finances and other items permitting. The efforts of the editorial and business staff in this respect have resulted in a more advantageous printing contract for this year, which will enable the printing of more articles per issue than formerly and will also effect a considerable saving to the members in the cost of reprints. New policies approved at St. Louis and decisions made by the Executive Committee will be introduced into the JOURNAL as quickly as possible. Dating of manuscripts will probably begin with the June number. Manuscripts, beginning with most papers of the St. Louis meeting, will be sent to the Advisory Committee and the general principle of priority will be followed as soon as possible.

Members should carefully read the rules on the inside back cover page governing the preparation of manuscripts intended for publication in the JOURNAL. The rules are going to be impartially and rigidly enforced and manuscripts will be returned to authors for revision or correction without hesitation.

The editor hopes that the new appearance and arrangement of the JOURNAL will meet with the approval of the majority of the membership. Constructive criticisms will always be welcome. Part of the responsibility of making the JOURNAL reflect the ideals and accomplishments of the Association rests with each member.

Reviews

Insect Enemies of Shade Trees, by GLENN W. HERRICK. 1935. 417 pp., 321 figs., indexes. Comstock Publishing Co., Inc., Ithaca, N. Y. $5.

The advent of a new book on shade-tree insects is of interest to all entomologists. For eleven years Felt's "Manual of Tree and Shrub Insects" has been the handy reference work on the subject, and prior to its publication Houser's "Destructive Insects Affecting Ohio Shade and Forest Trees," published in 1918 as Bulletin 332 of the Ohio agricultural experiment station, was the standard. In 1932 there appeared the book by Felt & Rankin, "Insects and Diseases of Ornamental Trees and Shrubs." Undoubtedly this is a convenient book for the tree owner, but it is probably less useful to the entomologist than Felt's "Manual" because it gives only brief accounts of the more important insects, and there are fewer illustrations of insects. However, as new pests are constantly appearing and new insecticides and methods of control are being developed each year, every new treatise on the subject is bound to contain some information either about pests or control measures not found in the earlier works.

In some respects Herrick's book is a distinct improvement over the others. It begins with a chapter on "The Value of Shade Trees and General Methods of Protection from Insect Attack," and is followed by "The Materials and Apparatus for the Control of Tree and Shrub Insects," and "Suggestions for the Treatment of Weakened Trees." Then follows 24 chapters, each dealing with a species of tree, or group of trees, arranged in alphabetical order by their common names. The three final chapters deal with "Insect Enemies of Smaller Trees and Shrubs," "Insect Enemies of Evergreens Other than Pines," and "Some Miscellaneous Insect Enemies of Trees and Shrubs." The book has an index to trees and shrubs and a general index.

One important feature of the new book is that under each kind of tree is given notes on the characteristics of the tree with an illustration. This undoubtedly adds to its interest for the non-entomologist. No keys to insects or types of injury under each heading are included, but in general the insects are treated in the following order: 1. Beetles (order Coleoptera), 2. Moths (order Lepidoptera), 3. Sawflies (order Hymenoptera), and 4. Scales and Aphids (order Homoptera). The principal insects injuring each kind of tree are described under these headings, and at the end of each is given the names of lesser pests which may also be found on that kind of tree. At the end of the description of each of the more important pests is given one or more references to literature for the benefit of those who may desire more complete information.

The writer of this review fully realizes the difficulties in the organization of such a book and in selecting the pests to be included. Each author will naturally be guided by his own experience and by the insect conditions in his own state or locality. In looking through Herrick's book the reader may wonder why apple (and possibly cherry) should not be included as a shade tree inasmuch as some residential properties have no other. This would make a more logical place for the eastern tent caterpillar than under willow. The question may also be raised whether spruce and hemlock are not sufficiently important trees for chapter headings. Surely each has its insect pests.

In looking at the insect enemies of birch, one notes the omission of *Phyllotoma nemorata* Fall., the sawfly leaf miner present in Maine and New York birch forests, and *Croesus latitarsus* Norton, a sawfly, the larvae of which are so conspicuous when feeding around the margins of the leaves. Then, too, in some localities in Connecticut the little green weevil, *Polydrusus impressifrons* Gyll., *Dichelonyx elongata* Fabr., the rose chafer, *Macrodactylus subspinosus* Fabr., the June beetles, *Phyllophaga* sp., canker worms, and the fall webworm, are often found feeding upon birch and might well have been cross-indexed as minor pests. The eastern tent caterpillar is also occasionally found on birch. In Herrick's book the apple and thorn skeletonizer, *Hemerophila pariana* Clerck, is placed under birch. Although this insect has been recorded from birch, the present writer has never seen it on that host, and it would seem to be more appropriately placed under mountain ash, hawthorn, or better yet under apple if that tree had been made the subject of a chapter. The gypsy moth should perhaps be under oak, a favored food tree in forests. Under pine, the omission of *Pinipestis zimmermani* Gr. is noticed. In Connecticut the white-marked tussock moth sometimes defoliates horse-chestnut, a sawfly, *Tomostethus bardus* Say, feeds upon ash, the green elm beetle, *Altica ulmi* Woods, occurs on elm, and caterpillars of the cynthia moth feed upon ailanthus near the coast, all of which have been omitted under these trees in the book.

After all, the inclusion or omission of such pests is only a matter of opinion. On page 76, *Hylurgopinus opaculus* (*Hylesinus opaculus* Lec.) is given among other beetles which may attack elms. Swaine concluded (Canadian Bark beetles, p. 74) that this is a synonym of *Hylurgopinus rufipes* Eich. On page 122 is listed the red-shouldered shot-hole borer, *Xylobiops basillare;* on page 221 apparently the same beetle is listed as the red-shouldered twig-borer, *Sinoxylon basillare.* In the list of common names of insects adopted by the American Association of Economic Entomologists, and also in Annand's "Adelginae of North America," page 126, the scientific name of the pine bark aphid is *Pineus strobi* Hart., instead of *Chermes pinicorticis* Fitch. Likewise Fisher (Bulletin 145, U. S. Nat. Museum) quotes Dr. Obenberger (in footnote, p. 209) to the effect that the rose stem girdler is not *Agrilus viridis* var. *fagi* Ratz., but *Agrilus communis* aberration *rubicola* Abeille de Perrin.

These slight discrepancies do not detract from the usefulness of the book, which is well illustrated and printed on coated paper with few typographical errors. In the main both references and subject matter are well chosen and presented, and the book will be exceedingly useful to entomologists, foresters, superintendents of trees and parks, commercial tree experts, town tree wardens and the owners of large estates. It should find a welcome place in every public library.

W. E. Britton. 1-2-36

Our Enemy the Termite, by Thos. E. Snyder. 1935. xii+196 pp., 56 figs., frontis., gloss., index. Comstock Publishing Co., Inc., Ithaca, N. Y.

Dr. Snyder writes, "My purpose is to give an accurate, plainly understandable but also interesting account of the life habits of termites, their damage, and methods of control based on a knowledge of their biology." In preparing the book he has used records and illustrations of the U. S. Bureau of Entomology and Plant Quarantine, together with many interesting personal experiences. Some previously unpublished material has been included. The discussion of experiments in rearing and crossing termites, some of the material in biological control of termites and the discussion of "rackets" in termite control were among the new items of particular interest to this writer.

The main emphasis of the book is placed on the biology and control of *Reticulitermes* species, especially *flavipes.* This feature makes the book unique among such publications and of great value to entomologists working within the range of this species. Sufficient references are made to other termite groups to bring out similarities and contrasts in habits and control methods.

The chapter on artificial control is taken almost entirely from his previous publications and is exceptionally well organized, concise and informative. Dr. Snyder's opinions and conclusions have been based on years of research and on valuable experience. In this book he repeats his earlier statements, including "Radical reconstruction of the foundations is the only permanent and effective remedy for buildings which, usually because of original faulty construction, have become heavily infested." He also states, "In their own interest, house owners are cautioned not to accept for the control or elimination of termites any new or easy methods, such as fumigation or sprays, spraying of woodwork in place or soil poisons."

The book is well printed, apparently free of typographical errors and the illustrations are excellent. A complete glossary and extensive index are appended. The only important omission is that of a bibliography.

Neely Turner. 1-11-36

The Biology of Mayflies, With a Systematic Account of North American Species, by James G. Needham, Jay R. Traver, Yin-chi Hsu, assisted by specialists in certain subjects. 1935. xvi+759 pp., 162 figs., 40 pls., 1 colored. Comstock Publishing Co., Inc., Ithaca, N. Y.

This is a comprehensive volume summarizing the studies of Professor James G. Needham, covering a period of a third of a century or thereabouts, and the work of a number of collaborators during this period. The inclusion of the word "biology" in the major portion of the title is presumably justified on the broad ground that satisfactory biological knowledge is contingent upon accurate identification and the further fact that throughout

the systematic as well as the more evidently biological portion there are numerous illustrations of the nymphs, figures which aid greatly in the identification of the immature stages of this really important group.

A study of this material is amply justified on economic grounds, since the mayflies are well known as constituting an important part of the food of fishes. The insects occur in enormous numbers in various types of fresh water and feed upon aquatic vegetation, transforming this potential source of food to animal matter and this in turn forming an important part of the sustenance, directly or indirectly, of many food fishes. The authors point out that relatively little is known concerning the relation of these abundant insects to the welfare of fish, and yet, there is no question but that they are important sources of fish food.

It must be admitted that the major portion of this comprehensive volume is devoted to structural and taxonomic considerations, and yet, it is a necessary preliminary to a thorough understanding of the biologic and economic importance of this group. The authors are to be congratulated upon having brought into one volume such a mass of information regarding these little known forms. This book is an important contribution to the knowledge of aquatic insect life and the possibilities of developing methods which will materially increase the numbers of our fresh-water food fishes. Fishermen as well as biologists will find in this volume much of interest. The work is an extended contribution to our knowledge of these insects as well as a masterly digest of previous literature. It is an essential to all future students of Mayflies.

E. P. Felt. 1-15-36

Obituaries

Frank L. Simanton 1875–1935

Frank L. Simanton died suddenly at his home in Benton Harbor, Mich., January 18, 1935, as the result of a heart attack. He was born at Ashland, Ohio, September 12, 1875.

Mr. Simanton had been connected with the Bureau of Entomology and Plant Quarantine from 1911 until his retirement from the position of associate entomologist at Toledo, Ohio, in September 1934. His education was acquired at the University of Wooster, and Ohio Northern University. Upon completion of his degrees, Mr. Simanton spent three years teaching biology at the Iloilo Normal School in the Philippine Islands. Shortly after his return to this country in 1908 he began work with the bureau, specializing in fruit insects and their control. In 1921 he became fruit specialist at Berrien county, Michigan. In 1927 he reentered the Bureau of Entomology, and was assigned to the corn borer research laboratories at Monroe, Michigan, and Toledo, Ohio. He has contributed several bulletins and papers to the literature on control of fruit insects.

Mr. Simanton is survived by his widow and five children.

W. A. S. 2-11-36

H. L. Fackler 1894–1935

H. L. Fackler, a young man well known throughout Tennessee and highly esteemed by fellow members of the state horticultural society, died May 21, 1935, of a heart attack. Mr. Fackler was agricultural development agent for the L. & N. railroad, living in Knoxville and serving the east Tennessee and Georgia districts. He leaves a wife and daughter, to whom the Association extends its sympathy.

Mr. Fackler rendered conspicuous service to the state of Tennessee for eight years as assistant state entomologist. The nursery business of the state reflects the benefits received from his honest and courageous efforts. He resigned from state service to take up duties in the department of horticulture of the University of Tennessee Agricultural Experiment Station. After serving the station for several years he began the work which he held up to the time of his death, with the Louisville and Nashville railroad. While developing the strawberry-growing district at Armona, Blount County, he organized the first strawberry fruit show and community outing to be held in Tennessee. From this event originated the idea of a strawberry festival on a more pretentious scale. He may be considered the real founder of the West Tennessee Strawberry Festival.

Mr. Fackler's associates have sustained a great loss and will greatly miss the honesty, integrity and resourcefulness that marked his work.

G. M. BENTLEY. 2-17-36

Warren Elmer Hinds 1876–1936

Dr. W. E. Hinds, internationally known entomologist, and in 1933 president of the American Association of Economic Entomologists, died suddenly in his home at Baton Rouge, La., on January 11, 1936, of a heart attack resulting from a severe case of influenza in November.

He was born at Townsend, Mass., on September 20, 1876, and was reared on a farm. In 1899 he was graduated from Massachusetts Agricultural College. He continued his studies under Professor C. H. Fernald and Doctor H. T. Fernald, and in 1902 received a Ph.D. degree, the first to be issued by that institution, now known as Massachusetts State College. In partial fulfillment of this degree he presented the "Contribution to a Monograph of the Thysanoptera of North America," that set a standard for all future taxonomic work in this group and became a shining example for graduate students in entomology at that institution to emulate.

WARREN ELMER HINDS
President American Association of Economic Entomologists 1933

The thoroughness and care which he demonstrated in all his work, his characteristic energy, and ability to present his thoughts clearly, early singled him out. In 1901 he was appointed an expert assistant in the Bureau of Entomology and lectured in Maryland during the summer.

Dr. L. O. Howard at once recognized the ability of the man, and upon his graduation in 1902 appointed him as special field agent to go to Victoria, Tex., and aid Dr. W. D. Hunter in the most intensive study of an insect that had probably ever been undertaken up to that time. "Practically all of the labor of preparing detailed outlines and of executing or supervising the execution of the laboratory work developed upon the junior author, Mr. W. E. Hinds, who has been in charge of the boll weevil laboratory." This work, in the words of Dr. Howard, was "magnificent. It was monumental." Such was the beginning of his contribution to economic entomology in the south.

In March 1903 he married Edith Gray of Templeton, Mass. This account would not be complete without mention of the work of his wife. The observations and records by Mrs. Hinds on the biology of mosquitoes at Victoria were valuable contributions.

In 1907 Dr. Hinds resigned from the government service to become head of the department of zoology and entomology at the Alabama Polytechnic Institute and entomologist of the Alabama agricultural experiment station. His pleasing personality, tact, and consideration for others soon won him a warm place in the hearts of the many friends he made in Alabama and later in Louisiana. He remained in Alabama until 1924, when he accepted the position of entomologist of the Louisiana experiment station and extension service, later devoting all his time to the experiment station position, which he held until his death.

In 1926 he obtained a leave of absence from his duties in Louisiana to accept an invitation from officials of the government in Peru to serve on a mission to study and make recommendations regarding the cotton pest problems of that country.

His second foreign commission came with his appointment as one of the delegates of the American Association of Economic Entomologists to the centennial of the French Entomological Society and the Fifth International Congress of Entomology held at Paris, France, in July 1932.

Dr. Hinds was a fluent writer and his publications cover a broad field in entomology. In addition to his works on thrips and cotton insects he published on stored products insects, fumigation, truck crop insects, and sugar cane pests. Altogether, he is credited with more than one hundred papers in "Who's Who in America."

A remarkable versality, coupled with a willingness to serve, brought heavy demands upon his time and energy. He was active in civic affairs and served in several capacities and on numerous committees for the American Association, was president of the Cotton States entomologists for many years, and honorary vice president of the Texas Entomological Society, and a member of the Washington Entomological Society. He became a fellow of the Entomological Society of America and the American Association for Advancement of Science. In South America he received the honor of election to membership in Centro de Scienceas, Letras e Artes, Brazil.

The home of Dr. and Mrs. Hinds was always open. They had no children of their own and for years these entertaining people have counted their student friends by the hundred.

Always congenial, his philosophy of the science and practice of economic entomology as expressed in his own words was a "happy field of investigational adventure and of satisfactory, helpful service to our fellow men."

To those of us of more recent years Dr. Hinds was looked upon as one of the youngest and latest of the pioneer entomologists. In his death the south and the nation lost a distinguished entomologist and a high type Christian man.

He was buried at Templeton, Mass., and is survived by his wife and four sisters.

F. L. Thomas, *College Station, Tex.* 2-18-36

Foster H. Benjamin 1895–1936

Foster H. Benjamin, associate entomologist on the staff of the Division of Insect Identification, died at Georgetown hospital in Washington, D. C., early January 24, after an illness of about ten days. Pneumonia was the cause of death.

Mr. Benjamin was born in Brooklyn, N. Y., September 17, 1895. His undergraduate studied at Cornell were interrupted by service in the lighter-than-air aviation unit of the U. S. Navy from April 1917 until the end of the war. He obtained a B.S. degree from Cornell in 1920, and an A.M. degree the following year from the same institution. In 1921 and 1922 he was assistant entomologist of the Mississippi State Plant Board, and from 1922 to 1927 curator of the William Barnes Museum at Decatur, Ill. Following this he was associated with the investigations on the Mexican fruit fly at Brownsville, Tex., being attached to the Plant Quarantine and Control Administration; and in 1929 he was transferred to Florida where he had an active part in the campaign against the Mediterranean fruit fly. Finally, in 1931, he joined the taxonomic staff of the Bureau at Washington, being stationed at the National Museum. Here he remained until the time of his death.

In 1920 he married Mary Anne Sheridan, of Ithaca, N. Y., who, with their two children, Richard, 13, and Mary Julia, 6, survives him. From boyhood, Mr. Benjamin collected and studied Lepidoptera, and he had become an outstanding authority on North American Noctuidae. In recent years he had, in addition, conducted intensive studies on the taxonomy of Trypetidae, especially the genus *Anastrepha*. His untimely death is greatly regretted.

C. F. W. M. 2-5-36

Joseph Ujhelyi 1882–1935

It is with regret that the many friends and acquaintances of Mr. Ujhelyi will learn of his death from apoplexy while on an insect-collecting trip at Debrecen, Hungary, on June 29, 1935.

Mr. Ujhelyi was born in Budapest in 1882. At 20 he joined the staff of the Hungarian National Museum at Budapest, where with the exception of the war years he served in various capacities until his retirement early in 1934. He was a member of several of the large collecting expeditions sent by this museum to South America, West Africa, the Balkans and Italy. After his retirement Mr. Ujhelyi devoted his entire time to his special interests in entomology.

He faithfully served the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in their parasite introduction program from central Europe

from 1922 until his death. His work was inestimably valued by the following members of the bureau with whom he was associated: S. S. Crossman, R. T. Webber, P. B. Dowden, C. F. W. Muesebeck, R. C. Brown and W. F. Sellers.

Mr. Ujhelyi was well known to foreign scientists, including many from the United States, for who could forget his inimitable manner and friendliness with which he dealt with visitors? Those of us who were more closely associated with him can but hope to remember him as loyally as he served us and held us in his memory until the last.

W. F. S. 2-11-36

Current Notes

DURING OCTOBER 1935 the Forest Insect Laboratory of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, was moved from Denver to Fort Collins, Colo. Dr. J. A. Beal is continuing in charge.

MR. HOWARD HAINES MURPHY has been appointed Commissioner of Agriculture for Massachusetts, replacing Mr. Edgar L. Gillett.

THE BODY OF THE LATE Dr. Karl F. Kellerman, of the Bureau of Entomology and Plant Quarantine, and one time assistant chief of the Bureau of Plant Industry, was removed on November 4, 1935, from its original resting place in Cumberland, Md., to Rock Creek cemetery, Washington, D. C.

ON JANUARY 21, 22 AND 23, 1936, the Tennessee State Nurserymen's Association held their annual convention at Knoxville. A full and interesting program, involving talks on nursery problems, field trips and demonstrations, included a report by Professor G. M. Bentley, who is secretary and treasurer of the association, a talk on "Insecticides" by Dr. F. Markovitch, and one on "Steps to be taken in regard to trucking uninspected nursery stock into Tennessee," by Lee McLain.

DR. J. FRANKLIN YEAGER has been appointed entomologist in the Division of Control Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, and is stationed in the new laboratory of the Bureau at the National Agricultural Research Center, Beltsville, Md. Since 1931 he has been associate professor of physiology of Iowa State College. At Beltsville he will continue his investigations on the physiology of insects.

DR. CHESTER I. BLISS, after two years of study with Professor R. A. Fisher at the Galton Laboratory, University of London, has accepted a three-year appointment at Leningrad as a specialist. His new address is Toxicological Laboratory, Institute of Plant Protection, Yelagin, Ostrov 4, Leningrad 47, U.S.S.R. Dr. Bliss' work will involve experimental and statistical investigations of insect toxicology and he will also act as consultant on the design of experiments and the analysis of experimental data. He is the first foreign specialist to be appointed to the institute.

M. G. FARLEMAN has resigned as instructor in entomology in the Department of Entomology, Michigan State College, to go with the California Spray Chemical Company, and Mr. Curtis W. Sabrosky has been appointed to succeed him.

Horticultural Inspection Notes

VETCH WEEVIL INFESTATION in Delaware, Maryland, New Jersey, North Carolina, Pennsylvania and Virginia is the subject of quarantines recently placed by the states of California and Washington. Under this quarantine, vetch seed is required to be fumigated before being shipped from the above states. A similar quarantine was placed by the state of Oregon last April.

AN AMENDMENT, dated September 11, to the Oregon quarantine relating to narcissus bulbs provides that certified narcissus bulbs taken from crâtes or other original containers for reshipment into the state of Oregon in small lots are required to be labeled by the shipper to show that the bulbs were certified at origin.

THE ARIZONA QUARANTINE (No. 4) relating to the red scale was amended on October 14 to require vacuum fumigation of the following plants before being released for planting

in the state: Cassia or Senna, Catha, Fig vine, Sweet broom (Spanish broom), Chinese hibiscus, Jasmine, Laurels (sweet bay), Australian tea-tree, California laurel, and Viburnum.

E. L. CHAMBERS, STATE ENTOMOLOGIST of the Wisconsin Department of Agriculture and Markets, was reelected treasurer of the Wisconsin State Horticultural Society at their recent annual meeting in Milwaukee. At the annual convention of the Wisconsin Nurserymen's Association held February 11 in Milwaukee, he discussed "Recent Developments in Nursery Inspection Work."

REPRESENTATIVES FROM 34 STATES, Canada and Mexico were in attendance at the annual meeting of the Plant Quarantine and Inspection Section held at St. Louis on December 30. M. S. Yeomans, state entomologist of Georgia, was elected chairman and E. L. Chambers, state entomologist of Wisconsin was relected as their secretary.

AN INVITATION has been issued by M. S. Yeomans, state entomologist of Georgia, to other state-certifying agents interested in the problem of the certification of tomato plants and seed to attend a conference at Tifton Ga. May 11 and 12 to discuss the problems of an adequate certification.

T. L. AAMODT, ASSISTANT STATE ENTOMOLOGIST of the Minnesota Department of Agriculture, Dairy and Food, was elected president of the Minnesota State Horticultural Society at their recent annual meeting in St. Paul.

THE NATIONAL PLANT BOARD has accepted an invitation to meet with the Central Plant Board at their annual conference at the Iowa State College in Ames, Iowa, on March 4 and 5. The North Central States Entomologists and the National Codling Moth Conference will hold their meeting at the same place on March 3 to 6 inclusive.

AFTER A RECENT CONFERENCE between the quarantine officials of the state of Texas and those of the U. S. Department of Agriculture, the shipping season for citrus fruit from those counties of that state under the Mexican fruit-fly quarantine was extended provisionally to include March 31, 1936. In announcing this extension to the close of the normal shipping season, Lee A. Strong, chief of the Bureau of Entomology and Plant Quarantine, explained that if conditions of reinfestation occur or if growers fail to observe sanitary requirements and fail to comply with clean-up restrictions, it may be necessary to set an earlier date.

FIVE-LEAFED PINES may be shipped intrastate in Ohio only when grown in Ribes-free zones, according to regulations established by the director of agriculture of Ohio, effective October 15. Nurserymen growing five-leafed pines in insufficient quantity to establish such zones are required to abandon the growing of this species, and pines purchased for redistribution from premises which are not Ribes free must not be held for sale on such premises during the season when the rust is spreading from Ribes to pines. The European black current is declared a public nuisance. State forests and municipal parks now growing white pines in a sufficient quantity are declared white-pine growing areas, and currant and gooseberry plants may not be grown within 900 feet of them. Control areas may be established for a distance of 900 feet from native or planted white pine areas and for a distance of 1500 feet from nursery plantings "which have sufficient value to warrant such classification."

A RATHER EXTENSIVE SURVEY of nursery stock transportation by other means than railroads into and within Minnesota has just been completed, according to A. G. Ruggles, state entomologist. A transit inspection system for nursery stock is being planned which will include the trucking system and the movement of plant products by airplane, both interstate and intrastate.

BULLETIN NO. 70 issued by G. M. Bentley, state entomologist of the Tennessee Department of Agriculture, has just been released which contains a list of nearly 700 nurseries, greenhouse and strawberry plant growers which have been inspected and certified.

ALL NURSERY STOCK entering the state of Arizona for propagating purposes shall be free from paraffin, wax or other coating which may hamper inspection, according to Regulation No. 4 placed by the Arizona commissioner of agriculture and horticulture on December 10.

PROCEEDINGS OF THE FORTY-EIGHTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The 48th annual meeting of the American Association of Economic Entomologists was held in the Hotel Jefferson, St. Louis, Mo., December 13, 1935, to January 1, 1936. The total registration was 246 members and visitors.

On Monday, December 30, the Section of Plant Quarantine and Inspection opened the meetings with morning and afternoon sessions. At noon, a joint session with the Entomological Society of America was held for the address of President L. A. Strong. The Section of Apiculture held its program in an afternoon session, and the evening was devoted to the program of the Section of Extension.

On Tuesday morning, December 31, the morning program was devoted to the opening business session and reports of delegates from various entomological meetings during the year. An invitation paper was presented by Professor W. C. O'Kane, on the Crop Protection Institute. The rest of the morning was given over to the reading of papers.

The afternoon session was opened by an invitation paper by Dr. J. G. Sanders, on commercial entomology. The balance of the afternoon was devoted to the reading of papers. The program was run in two sections because of the large number of papers.

On Tuesday evening the entomologists' dinner was held with an attendance of 209. A very enjoyable program of music and entertainment was furnished, following which Dr. C. P. Classen presented the annual address of the Entomological Society of America. Much credit is due the local committee for the arrangements for and conduct of the banquet and the members were unanimous in their commendation.

Wednesday morning, January 1, was devoted to a program of papers, preceded by an invitation paper by Dr. C. J. Drake, on teaching and training in entomology.

The afternoon session was devoted to a symposium on orchard sanitation, led by Vice President J. J. Davis and featured by the addresses of Drs. D. L. Van Dine, G. W. Keitt and E. C. Auchter.

The symposium was followed by the closing business session and the meeting was adjourned at 3:30 p.m.

Upon recommendation of the Executive Committee and vote of the Association, the choice of the time and place of the next annual meeting was left to the Executive Committee, with the understanding that it would not be held in Washington. L. S. McLaine of Ottawa, Canada, was elected President for 1936.

EXECUTIVE COMMITTEE MEETING

The annual public meeting of the Executive Committee was held at 8 o'clock Monday evening, December 30, 1935, in the Gold room of the Hotel Jefferson, St. Louis, Mo. President L. A. Strong presided. Reports

of various committees were read and actions deemed necessary in connection with these reports were incorporated in the report of the Executive Committee.

The following reports were presented:

REPORT OF THE REPRESENTATIVE TO THE NATIONAL RESEARCH COUNCIL

The annual meeting of the Division on Biology and Agriculture of the National Research Council which was held in Washington April 20, 1935, was attended by your representative as one of the advisory representatives of section VIII. The full and voting representative for section VIII for this period rests in the delegate of the American Society of Mammologists, Remington Kellogg. The annual meeting dealt largely with routine business and the consideration of reports and recommendations from various committees.

In the discussion of the report of the Committee on the Ecology of Grasslands in North America it was pointed out that entomologists were interested in any scientific study of grasslands, especially those located in the main grass areas of the west and middle west. Insects may play a very important part in successions of plants and it is desirable that their relations to the complex be understood. Reference was made to the recent grasshopper outbreaks, to the relation of grasslands to control of the sugar beet leafhopper and other examples where insects play an important part in the ecology of grasslands. Those present at the meeting believed it desirable that an effort be made to have a number of areas of native grasslands set aside for scientific study. These should be located in several states and be under the general direction of the state experiment station and studied in cooperation with the U. S. Department of Agriculture. Attention was called to one area in Missouri which is being handled by state agencies. The chairman was authorized to appoint a committee of five to look into the question and confer with representatives of federal and state governments to see what could be done.

The attention of entomologists is again called to the work by the Committee on Effects of Radiation on Living Organisms. The report of this committee has been mimeographed. The cumulative report covering the period 1928–1934, inclusive, contains 52 pages and summarizes results of work on radiation by the committee and others, including citations to literature and brief discussions of investigations carried on under grants made under the auspices of the National Research Council.

No report was presented by the Committee on Wildlife but a report was submitted by a subcommittee on The Training of Men for Administrative and Educational Work on Wildlife Problems. This report discussed standards in preparing and examining men for eligibility for work of this type, many of which are somewhat similar to those of the federal Civil Service Commission. It was requested that the report of the subcommittee be considered first by the main committee.

In considering the report on "Barro Colorado Island, Biological Laboratory in the Canal Zone," there was considerable discussion as to methods of providing funds for the continuation of this biological laboratory maintained under the auspices of the National Research Council. Various methods were suggested including one which involved the forming of a Barro Colorado Island society or association requiring the payment of small annual dues. No definite conclusions were reached. The chair appointed a committee to look into the question to consider the advisability of adopting more vigorous means of soliciting endowments or contributions from various individuals interested in the work.

Considerable time was devoted to consideration of the report of the Editor-in-Chief of Biological Abstracts. Under date of April 10, 1935, the National Research Council had been advised that the Rockefeller Institution would withdraw its support to Biological Abstracts. This apparently meant that the publication of the abstracts would have to be discontinued. Ways and means of financing the work were discussed in some detail as well as the need and advantages of this type of publication. The chairman was authorized to select representatives to make a special study with the idea of finding ways and means of continuing this important service to biologists. Subsequent to this meeting, a committee was appointed and considered the question in a meeting held in Washington during early autumn. It is understood that this committee conferred with many prominent individuals, including some cabinet members, and is preparing a plan to be submitted to Congress. The proposal may suggest the establishment of a semigovernmental organization supported by private and governmental funds to continue publication of Biological Abstracts. Dr. Herbert Osborn is a member of this committee. Subsequent to the meeting in April, a small amount of additional funds was made available which would provide for the neces-

sary work to complete the present volume. As the matter now stands, it appears that unless some new provision is made, Biological Abstracts will be discontinued at the end of the present volume.

In considering the nomination of a member on the Crop Protection Institute, there was considerable discussion as to the work of this institute. There seemed to be little definite information as to what the Crop Protection Institute is doing; how it obtains and accounts for funds; the relation it has to various institutions; and the relation the National Research Council has to the endorsement of materials developed in connection with the work financed under the Crop Protection Institute. Mr. Remington Kellogg of the Smithsonian Institution was nominated as a member on the Crop Protection Institute from the National Research Council and was requested to secure full information on these and other phases of the work of the Crop Protection Institute.

An appeal for the National Research Council to support the aims of the National Association of Audubon Societies and certain related activities was tabled.

The funds available for fellowships had been reduced from $50,000 to $37,500 for the year. A total of 179 applications for aid had been received, sixty of which were in biology, forty in zoology and twenty in botany. Very few, if any, of the applications referred directly to entomology and none were discussed in detail. In this connection attention is invited to the comments included in the report submitted to this Association last year, which are endorsed by your present representative.

The Division of Agriculture and Biology of the National Research Council voted to continue membership in the International Union of Biological Sciences and recommended that the dues of $270 be paid from funds available to the Research Council.

S. A. ROHWER

REPORT OF THE CROP PROTECTION INSTITUTE

For the year 1935 the Crop Protection Institute has maintained the following projects:

Copper fungicides.—A continuation of the work started three years ago for the Nichols Copper Company. Headquarters at the Delaware experiment station, under the supervision of J. F. Adams. The Institute investigator, A. A. Nikitin. This project has developed a new copper fungicide, copper zeolite, which has now progressed through two seasons of extensive field plots and is undoubtedly a superior material, more active per unit of copper than Bordeaux mixture, and of very much less bulk.

Copper in plant nutrition.—A project begun in March 1932 with funds supplied by the Nichols Copper Company and with headquarters at the Delaware experiment station, under the leadership of Thomas F. Manns. The Institute investigator is Walter L. Churchman, with additional help part of the season. Important results have been secured from the addition of relatively small amounts of copper sulfate to commercial fertilizer. On certain crops this results in a substantial increase in yield and in quality, making net return to the grower many times as great as the cost of the copper sulfate.

Copper pots and copper-lined benches.—A preliminary study which gave interesting results but not sufficiently significant or practical to warrant continuation.

Pyrethrum growing.—A continuation of work started several years ago with funds supplied by Stanco Incorporated. Headquarters at the New Jersey experiment station, under the leadership of T. J. Headlee. Most of the work now in Pennsylvania. Various problems connected with the commercial growing of pyrethrum in the United States have been solved and a large number of farmer contracts are now maintained by the Institute. The Institute investigator is R. E. Culbertson.

Nicotine in oil sprays.—A new project supported by the Monsanto Chemical Company, begun in July 1935 at the Illinois experiment station with the cooperation of the Illinois Natural History Survey, and under the leadership of W. P. Flint. The Institute investigator is C. W. Kearns. At present the work is concerned with incorporation of nicotine in oil sprays through new chemical measures. Other developments have been planned.

New organic compounds as contact insecticides or stomach poisons.—This project was begun in 1933 with Dow Chemical Company funds at the Iowa Experiment station and under the leadership of C. H. Richardson. The Institute investigator is J. F. Kagy. Many synthetic, organic compounds have been studied and several of

promise as contact insecticides or stomach poisons, or both, have been discovered. One of these, dinitro orthocyclohexylphenol, is particularly advantageous as a toxicant added to oils. This combination has now had two years of extensive field tests. Other lines of inquiry are under way.

New fumigating gas.—Proxate, a new fumigating gas, has been placed on the market as the result of a project completed in the fall of 1935. The work was supported by Liquid Carbonic Corporation funds at the Iowa experiment station, and was conducted under the supervision of C. H. Richardson by Institute investigator R. M. Jones.

Halowax oil.—A research project begun in 1932 with headquarters at Ohio State University, under the leadership of D. M. DeLong. E. P. Breakey is the Institute investigator. A successful means of utilizing the toxic properties of Halowax oil has been developed. During part of the year the project has had the services of A. C. Miller as an extra man

Sulfuric acid in weed control.—Supported by the Freeport Sulphur Company, this project was begun in October 1933 at the Davis substation of the California experiment station, under the leadership of W. W. Robbins. The Institute investigator is W. E. Ball. The work has resulted in successful control of certain weeds in farm crops, notably mustard in barley. Means of applying dilute sulfuric acid on a large scale have been developed. The work has now reached a commercial phase and the project was brought to a close in October 1935.

Carbon bisulfide in spray materials.—Study of the utilization of carbon bisulfide in spray materials has been supported by the Stauffer Chemical Company at the New Haven experiment station, and has been under the leadership of W. E. Britton. The Institute investigator is M. B. Anthony. At present the work is confined to development of formulae in the laboratories of the Stauffer company, and the Institute aspect of the work is in abeyance.

Pine oil in cattle sprays.—A project begun in February 1934, with funds supplied by Hercules Powder Company, and with headquarters at the Delaware experiment station, under the leadership of L. A. Stearns. The Institute investigator, A. M. Pearson. Extensive data were secured as to cattle sprays in which pine oil is incorporated, and the project was brought to a successful close in October of the present year.

Lead arsenate, improvements and substitutes.—This project was begun March 1934 and involves various lines of inquiry, notably the development of substitutes for lead arsenate, the development of improved calcium arsenate, and improvements in lead arsenate itself. Funds are supplied by General Chemical Company. The project leader is J. J. Davis, and much of the work is being carried out in Indiana. Other aspects have been provided for in various other states, including the east, the south and the far west. M. M. Darley is the Institute investigator, with other men from time to time as temporary assistants.

New spray base to increase toxicity.—This work, known as the DX project, was begun in January 1935 with headquarters at the New Hampshire experiment station, but with work in various states. Project leaders are J. F. Adams and W. C. O'Kane, and the men employed are G. L. Walker and William H. O'Kane. A new spray has been developed that operates to increase the toxic properties of various materials, including pyrethrins, nicotine, rotenone and several synthetic organic compounds.

Cuprous oxide.—A new project, begun in July 1935, has involved studies of the fungicidal activities of cuprous oxide. The work is financed by Rohn & Haas Company, with headquarters at the Geneva experiment station under the leadership of J. G. Horsfall. The Institute investigator is Robert O. Magie.

Exploratory work.—In addition to the above the Institute is carrying on preliminary studies for a number of corporations, including the Metals Refining Company, the General Dyestuffs Corporation, the United Fruit Company and the Grindrod Process Corporation.

Publications of the year are the following:

JONES, R. M., The toxicity of carbon dioxide-methyl formate mixture to the confused flour beetle *Tribolium confusum* Duv. Bulletin 49.

BREAKEY, E. P. and A. C. Miller, A method for comparing the ovicidal properties of contact insecticides. Bulletin 50.

BREAKEY, E. P., Halowax as an ovicide. Bulletin 51.

W. C. O'KANE, *Chairman*

REPORT OF THE TRUSTEE OF THE TROPICAL PLANT RESEARCH FOUNDATION

Your Trustee of the Tropical Plant Research Foundation has nothing new to report at this time. There have been no new projects undertaken and no immediate prospect of activity but the resources of the Foundation are being cared for by Acting Director Dr. Wm. Crocker at the Boyce Thompson Institute, and projects can be undertaken when satisfactory financial support is available. The need of entomological research in the tropics is very apparent and any encouragement that can be given by members of the society will, I am sure, be welcomed by the trustees of the foundation, and the active interest of the society fully appreciated.

HERBERT OSBORN, *Trustee*

REPORT OF THE COMMITTEE ON NOMENCLATURE

Your Committee on Nomenclature submits herewith a list of 125 common names for the consideration of the Association, as additions to the approved names, and a list of 11 common names which have been adopted but for which a change in name has been suggested. It is suggested that as heretofore these lists be sent to all members of the Association in order that they may have opportunity to vote on the names.

Since the publication of a complete list as a separate in 1931, the Association has approved two supplemental lists, which were published in the JOURNAL **26**(6):1169–70, **28**(4):726–27. For the convenience of the members we propose that the Association authorize the committee to compile the list of approved names, including those adopted this year, to be published in the JOURNAL OF ECONOMIC ENTOMOLOGY, and also be issued as a separate and offered for sale at cost.

We move that this report be accepted without reading the names and that the committee be authorized to proceed as above suggested.

J. A. HYSLOP, *Chairman*
E. O. ESSIG
H. B. HUNGERFORD
H. G. CRAWFORD

[The list has been submitted to the membership and the approved list will appear in a later issue.]

REPORT OF THE BOARD OF TRUSTEES OF THE PERMANENT FUND

During the year 1935 additions to the fund have been made from accrued interest from securities and savings deposits; from interest adjustments on the exchange of Liberty bonds (called) for U. S. Treasury bonds and from additions to the fund of $300 from the Association account as voted at the Pittsburgh meeting.

During the year a portion of the cash balance was withdrawn from the bank deposits for the purchase of U. S. savings bonds. The fund has been audited and the report of Ernest L. Millington, state accountant, will be found with the other financial reports of the Association.

A. I. BOURNE, *Chairman*
L. A. STRONG
A. F. BURGESS
P. J. PARROTT
L. S. MCLAINE

REPORT OF THE JOINT COMMITTEE ON INSECT COLLECTIONS OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS AND THE ENTOMOLOGICAL SOCIETY OF AMERICA

Last year for the first time committees on insect collections for the American Association of Economic Entomologists and the Entomological Society of America reported as a single or joint committee. Since the data on private collections had been published by the American Association of Economic Entomologists, it was the thought of the joint committee that this Association should continue to print this part of the report and that the Entomological Society of America should continue to print that part of the report dealing with institutional collections. This procedure met with the approval of both societies and as a result that part of your joint committee's report dealing with private insect collections was published in the JOURNAL OF ECONOMIC ENTOMOLOGY **28**(1):6–8, Febru-

Summarized Data on Private Collections—1935

	Mrs. Vitae Kite, Hollister, Mo.	M.D. Leonard, New York, N.Y.	O.L. Cartwright, Clemson College, South Carolina	J.G. Watts, Clemson College, South Carolina	David Dunavan, Clemson College, South Carolina	G.E. Moore, Lebanon, Mo.	H.E. Jacques, Iowa Wesleyan College, Mt. Pleasant, Iowa	Ralph Voris, State Teachers College, Springfield, Mo.
Groups Represented	Lepidoptera	Aphiidae (Homoptera)	Coleoptera, especially Scarabaeidae	Thysanoptera / Chrysomelidae	Carabidae, Dytiscidae, Hydrophilidae, Haliplidae (Coleoptera)	Rhopalocera (Lepidoptera)	All Iowa insects	Staphylinidae (Coleoptera)
Geographical distribution of collections	Hollister and vicinity; some exotics	North America	Mostly North America	World, mostly No. Amer. / Eastern No. Amer	North America	Chiefly North America		North America
No. specimens in collection	8000	2000 slides	22,000	2000 slides / 6500	6000	247	70,000	45,000
No. species in collection	335	265	800+	200 / 500	450	118	5000	?
No. holotypes in collection	None	None	None	5 / None	None	None	?	None
No. paratypes in collection	None	None	36 species	16 / None	6	None	?	None
Is collection available to other workers	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Plans for disposition of collection	Not certain	Cornell University	None	None	None	None	University of Iowa	?
Will you determine species in your specialty	Yes	Yes, also exchange	Yes	Yes / No	Haliplidae only		?	Genus Philonthus only

ary 1935. The report of institutions administering insect collections was published in the Annals of the Entomological Society of America 28(1):183–89, March 1935.

This year your committee has again sent out to entomologists and entomological centers questionnaires similar to those sent out last year requesting data concerning private and institutional collections. Since the data for institutional collections are published by the Entomological Society of America the data concerning private collections only are included in this report.

Reports concerning private collections numbered sixteen in 1933 and seventeen in 1934. In the report for 1934 it was suggested that probably after a period of a few more years there would be very few private collections of importance which had not been reported to the committee and that such a report as this might lapse for a few years until a new group of private collectors had been developed. Evidence that this prophecy is correct is indicated by only eight reports being submitted this year.

Your committee therefore suggests that no effort be made to secure information on private collections for a period of several years because results from this type of activity for the next two or three years are certain to be negligible. We do feel however that this committee should be continued because of its possible service to entomology as a factor in the better protection and development of insect collections in America.

By action of the presidents of both societies, T. H. Frison has served as chairman of this oint committee.

T. H. Frison, *Chairman* (American Association of Economic Entomologists)
H. H. Knight (American Association of Economic Entomologists)
F. F. Lutz (Entomological Society of America)
J. H. McDunnough (Entomological Society of America)
C. F. W. Muesebeck (Entomological Society of America)
E. C. Van Dyke (American Association of Economic Entomologists)

REPORT OF CODLING MOTH COMMITTEE

The activities of the Codling Moth Committee have continued along the lines outlined in previous reports. In January 1935 the summary of information obtained by various codling moth investigators throughout the country during the growing season of 1934, referred to in last year's report, was completed, mimeographed and circulated as unpublished data for the information of those interested. This was done by the Bureau of Entomology and Plant Quarantine, at the request of this committee. Comments that have been made to the committee indicate that these summaries have served a useful purpose and arrangements have been made for the preparation and circulation of a similar summary of the results obtained during the 1935 growing season. This information will be made available to interested entomologists during the month of January.

A second activity of the Codling Moth Committee was the arranging for a conference, which was held at Urbana, Ill., February 26 and 27, 1935. Approximately eighty entomologists and other workers from twenty-two states were registered at the conference. The committee is indebted to Mr. W. P. Flint and others of the Illinois Natural History Survey, for inviting the conference to Urbana and for furnishing stenographic and other services.

The committee has voted to accept an invitation received from Prof. Carl J. Drake to hold the next conference at Ames, Iowa, March 3 and 4, 1936, in conjunction with the annual meeting of the North Central States Entomologists.

B. A. Porter, *Chairman*
P. J. Parrott
W. A. Ross
G. M. List
W. J. Schoene
J. S. Houser

REPORT OF THE COMMITTEE ON RESEARCH WORK ON THE CONTROL OF THE EUROPEAN CORN BORER

A year ago a brief résumé of the status of the European corn borer, and particularly the results of the previous ten years of research, was presented by this committee. Perhaps the outstanding observation to be reported at this time is the fact that the results of research, which heretofore have been reported as promising, have gone beyond the stage of promise

and may be recognized as definite and practical factors for reducing borer populations in the future.

During the current year, with conditions more favorable for the borer than for several years past, there has been a marked increase in borer abundance in all but four of the states known to be infested, also in the provinces of Ontario and Quebec in Canada, and an appreciable increase in damage in the older areas of infestation. Notable records of distribution show, among other things, that destructiveness has continued in the Connecticut river valley of Massachusetts and Connecticut and on Long Island, and that a similar situation is developing southward along the coast into Virginia; that there appears to be a definite tendency for the one-generation borer in the central west to establish itself as a two-generation borer as it moves southward; and that the borer population in the central west has increased at a greater rate distant from the region influenced by the lakes.

Careful studies by federal workers indicate the possibility of an accurate zoning of regions throughout the country for predicting areas of one and two-generation borers. These studies indicate a transition zone between the one and two-generation regions, in which there is an inhibition in the development, and consequently the destructiveness, of the borer. If the correctness of these theoretical zoning studies continues to be substantiated by field observations, the information should be of very great value in the future.

Within the past year or two the investigations of both federal and state agencies have become stabilized. Certain phases of the work which now are clearly of little or no value in practical control have been dropped, others which have been mastered so far as research is concerned have also been temporarily discontinued, while the investigations of known promise which require additional study are being vigorously continued.

Completed investigations of notable value include harvesting and cultural devices, particularly low-cutting implements and plowing attachments to insure coverage, and rate and date of planting studies. The former need further demonstration while the latter need confirming experiments in new localities. Studies in progress which demand further research include parasite introduction, varieties of corn that are tolerant or resistant and tolerant, and insecticides. In the *parasite studies* two imported species of parasites stand out as the most promising natural checks on corn borer increase. The studies show very clearly that the utilization of parasites has gone beyond the point where they show promise and are now a definite factor in reducing the borer population within the range of spread from the points of earliest liberations. Studies on *varietal resistance and tolerance* of corn have shown marked progress with definite assurance of practical utilization. Certain fundamental facts have been developed and certain plant characteristics, such as delayed tassel eclosion, show definite resistant qualities. However, closer cooperation with plant breeders is essential, and deeper research into the fundamentals of host resistance is needed. *Insecticide* studies have resulted in the development of effective controls which may be practical in areas where sweet corn and other affected crops are of high commercial value but there is need for further work to obtain information upon controls which will be practical for the average grower, and methods for their application. It should be noted that information of great value in other lines of insect control has been secured as a result of the corn borer investigations.

Your committee reiterates six of its recommendations made a year ago, which include: (1) infestation and population surveys, (2) further study of resistant and tolerant varieties of sweet and field corn, (3) continuation of parasite studies as during the past year, (4) further investigation of insecticides and methods of their application, (5) detailed and comprehensive studies on the natural and artificial ecological factors as they relate to the distribution and destructiveness of the corn borer, including further studies on zonal ranges of one and two-generation borers, and (6) the application of the results of past research in new areas of infestation to determine their suitableness to meet situations which exist in the new environments. In addition it is recommended that a plant breeder work with the entomologists of the federal station studying tolerance and resistant characters in corn plants. Also, inasmuch as the borer has spread into Virginia and shows a high potentiality under conditions not heretofore studied, that a station be established in that region.

J. J. Davis, *Chairman*
G. A. Dean
Lawson Caesar
D. J. Caffrey
A. B. Baird

REPORT OF THE COMMITTEE ON TRAINING OF ENTOMOLOGISTS

No formal report was presented inasmuch as the subject is covered by the invitation paper, "Teaching and Training in the Field of Entomology," by C. J. Drake, chairman of this committee. (See p. 28.)

REPORT OF THE COMMITTEE ON ADVANCEMENT OF OFFICIAL ENTOMOLOGY

This committee has little to report for the present year. As is well known, there have been several allocations of emergency funds for increases in various phases of entomological activity, with the result that unemployment of entomologists is less serious than it was a year ago. On the other hand it is assumed that it is the desire and hope of all entomologists that there may soon be a marked reduction in the use of emergency funds and that the continuation of entomological work of an official nature may be made possible on regular appropriations. Since it is now happily predicted that there may before long be a reduction in the need for emergency funds, we look forward to a period when it will be desirable for entomologists to safeguard the official work in which they are interested by attempting to see to it that the necessary items are included in regular appropriations. It is perhaps safe also to assume that with a reduction in the use of emergency funds there may be a tendency to reduce the funds available for official entomological work, and that if this work is to continue to an extent warranted by the needs of the country it will be necessary to use every effort to safeguard the appropriations for entomological investigations and control.

In order that the entomological profession be suitably prepared for such changes as seem likely in the near future, the committee desires to recommend that at least three special conferences be arranged, to bring together men specially fitted for discussions in these fields, with a view in part to formulating desirable policies in the advancement of these somewhat neglected branches of entomology. At a meeting of the committee held early in the present year, we suggested that such conferences be held of men interested in the following fields: biological control, insect physiology, insect toxicology.

Some effort was made to enlist the support and assistance of selected men in each field, with a view to having them bring their colleagues together for such a preliminary conference, but without success to the present. In the opinion of the members of this committee, such conferences are still greatly to be desired.

The committee then respectfully recommends that the officers of this Association for the coming year take steps for the holding of such conferences in the fields above mentioned.

The committee also desires to recommend that it be continued, but with specific plans for a rotation of membership, so that when events so shape themselves that more effective work can be done on regular appropriations, the Association may be suitably organized to assist.

E. F. Phillips, *Chairman*
W. E. Britton

REPORT OF THE COMMITTEE ON INSECTICIDE TERMINOLOGY

Careful reading of published articles relating to the testing and application of insecticides will soon convince anyone that many authors fail to state satisfactorily the name or composition of the compounds or mixtures used by them, and give only obscure or even indefinite descriptions of the concentrations employed. The importance of careful attention to these details is obvious, for if the substances mentioned cannot be identified by the reader, or if the concentrations used are not known with certainty, the experiments cannot be duplicated for the purpose of checking the findings. This unsatisfactory state of affairs was recognized by Dr. F. L. Campbell of the U. S. Bureau of Entomology and Plant Quarantine, and it was at his suggestion that the President of the Association appointed a committee of five to take what steps they deem necessary to improve conditions.

It is strongly urged that every writer on insecticidal subjects keep constantly in mind the desirability of so defining a material that another investigator can with certainty buy or prepare the identical substance for further experimentation. It is recognized that this may be difficult in many cases, and that different problems are presented by different classes of materials, such as relatively pure substances (naphthalene), materials of lesser but somewhat standard composition (calcium arsenate, nicotine sulfate solutions), plant materials (pyrethrum, derris), and proprietary compounds.

In the case of pure substances the name alone will suffice, but care is necessary even here to give a name that will indicate the exact compound meant. For instance, if copper sulfate is mentioned, it should be definitely indicated whether the common form—the

one with five molecules of water of crystallization—is meant, and if sodium arsenate is referred to it should be stated whether the mono, di or trisodium compound is meant. This can be taken care of in some cases by the use of a specific name such as borax, which designates a particular form of sodium borate, and in many other cases in which the exact chemical names are cumbersome, as for instance disodium arsenate heptahydrate, by giving the formulas.

In the case of such commonly used insecticides as calcium arsenate and magnesium arsenate it should be made clear that the ordinary commercial material sold for insecticidal purposes is meant, and whenever possible the analysis, at least insofar as the content of active constituent is concerned, should be quoted. If in any case a pure laboratory compound is being used, as for example the definite tricalcium arsenate octahydrate, this fact should be made perfectly clear. If a solution of nicotine sulfate is referred to, the reader should not be left to infer that it was of the customary concentration of 40 per cent nicotine, but should be told that fact.

In the case of natural materials such as pyrethrum and derris, which are known to vary considerably, it is imperative that the content of the active principle be given.

The greatest trouble will be encountered in describing tests with proprietary materials. It is often difficult to determine with certainty the composition of such a material, yet without this information it is hardly worth while to publish the results. The use of the trade name will of course be of great assistance, but even so there is no assurance in many cases that the composition remains unchanged from year to year.

It appears to the committee that there is real need of an approved list of names of insecticides, just as there is need for an approved list of insect names. It is proposed to undertake the preparation of such a list, and to include under each material some specifications of the acceptable grade, with recommendations as to what components should be determined when it is necessary to describe it by its analysis.

In considering the question of expressing the concentrations of insecticides used, two problems are encountered, namely definiteness and uniformity. Naturally a reader can form no definite conception of the strength of a pyrethrum spray if, as occurred in one case, he is told that "one ounce of the commercial extract was diluted with four gallons of water and this sprinkled on the ground at the rate of one gallon to one square yard of surface," and then has no description whatever of the nature and concentration of the commercial extract. Also, great uncertainty may arise from the use of abbreviated statements such as "lead arsenate was used at 4–100," to mean that 4 pounds were used in 100 gallons of water. In another instance a writer stated that he had used "lead arsenate-Paris green-zinc sulfate-lime dust (5–1)1–(2.4–4)1" without describing his system of shorthand, and it required study to see that he meant he had used equal quantities of a 5:1 lead arsenate, Paris green mixture, and a 2.4:4 zinc sulfate, lime dust mixture. So long as there is no universally accepted system of abbreviations covering the description of mixtures, it is urged that every author state just what his abbreviations mean, no matter how obvious they appear to him.

It is probably impossible to attain absolute uniformity in the matter of stating concentration, but certainly there is much to be gained by some attempt in this direction. In describing sprays various writers use the expressions "one part to x parts," "per cent by weight," "per cent by volume," "pounds per so many gallons," and in some instances the different ingredients of the same mixture will be designated in different terms. Perhaps no one of the systems can be adopted in all cases, but when the expression "pounds per x gallons" is adopted, the x could always be made 100 and thus a certain degree of uniformity assured. In describing dusts the difficulties are not so great, since per cent by weight, or parts per unit part will almost always be used. In speaking of fumigations, the distinction between dosage or amount used, and concentration in the vapor phase needs to be sharply defined, and the accidental equality of the figures for milligrams per liter and ounces per 1000 cubic feet goes a long way toward simplifying the comparison of reports of laboratory and large-scale fumigations. In speaking of spray residues a great variety of expressions are used, and it would be well for authors to take some thought as to which is most suitable for the presentation of their particular points. From the standpoint of public health the concentration in terms of weight is considered most important, and deference to established custom will probably prevent the dropping of grains per pound in favor of the more logical parts per million; the entomologist who is interested in the problem of the relation between spray deposit and insect control might better focus his attention on surface concentration and the various expressions used, namely "mgs. per sq. cm.,"

"mgs. per sq. in.," and "mgs. per sq. ft.," could perhaps all be dropped in favor of micrograms per square centimeter, which gives figures of convenient size; when the effect of weathering is being studied, the amount per fruit becomes the important consideration, because it is independent of the growth of the fruit, which would affect both other forms of expression.

The committee is not prepared at this time to make specific recommendations on all these points, but would recommend that a standing committee be appointed to do so in future reports or special articles in the JOURNAL. In the meantime all members of the society who care to are urged to communicate their ideas on these subjects to any member of the committee.

CHARLES M. SMITH, *Chairman*
WILLIAM MOORE
M. D. FARRAR

REPORT OF THE EDITORIAL BOARD ON THE PUBLICATION OF THE INDEX

In the belief that the series of Indexes of American Economic Entomology should be continued, the editorial board outlined a project which was duly approved at the last annual meeting of the Association, JOURNAL **28**(1):22–3, conditioned upon compilation being made in the Bureau of Entomology and Plant Quarantine or by some other agency. It was not possible to arrange for the compilation of the Index in the bureau as in previous years, although we were assured that Miss Mabel Colcord, in charge of the library, would gladly supervise the compilation, provided provision was made for sufficient clerical assistance and supplies. The cost of this has been estimated at $6000 and to date no way of providing this sum has been found.

In view of the fact that the bureau librarian has characterized the Index as "really an indispensable tool to the bureau staff for quick reference work" and has further stated that "the published Indexes have proven for years invaluable time-savers to entomologists throughout the country," the committee is strongly of the opinion that due consideration of efficiency amply justifies the compilation of this work in the bureau and hereby expresses the hope that arrangements can be made which will make this possible during the coming year.

E. P. FELT, *Editor*
D. M. DELONG, *Associate Editor*
A. I. BOURNE, *Business Manager*

BUSINESS PROCEEDINGS

Tuesday Morning Session

December 31, 1935

The Tuesday morning session of the 48th annual meeting of the American Association of Economic Entomologists, held at the Jefferson hotel, St. Louis, Mo., December 30–31, 1935, and January 1, 1936, convened at nine o'clock, President L. A. Strong, Washington, D. C., presiding.

PRESIDENT STRONG: The first order of business is the report of the Secretary.

REPORT OF THE SECRETARY

A. I. Bourne
Amherst, Massachusetts

The membership at the Pittsburgh meeting totalled 1159 and included six life members. The present membership increased by elections, redistributed by transfers and decreased by resignations and deaths is 1150, comprising 718 active members, 378 associate and 54 foreign members. This is the first year since the peak of the depression in which the membership roll has substantially held its own and it is hoped this will prove an accurate index of the trend toward a return to normal conditions. During the past year we have suffered the loss by death of three active members, all of them young men of great promise.

SUMMARY OF CASH RECEIPTS AND DISBURSEMENTS AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the period from December 9, 1934 to December 14, 1935

	Total	Journal	Association	Index IV	Index III	Index I and II
Balance, Dec. 9, 1934 per previous report	$ 6,503.77	$2,999.38	$2,308.99	$306.77	$150.51	$738.12
Income						
Sales	70.50			29.00	15.50	25.00
Subscriptions, advertising and reprints	7,601.78	7,601.78				
Dues and miscellaneous	1,671.23		1,671.23			
	15,847.28	10,601.16	3,980.22	335.77	166.01	764.12
Expenses						
Auditing	35.00		35.00			
Printing	5,851.21	5,778.01	73.20			
Clerical work	450.00	320.00	130.00			
Editor's salary	200.00	200.00				
Postage	198.56	106.97	84.09	2.50	2.50	2.50
Telegraph, freight, telephone and express	36.46	30.18	6.28			
Secretary's salary	200.00	100.00	100.00			
Halftones and engravings	645.22	645.22				
Supplies and stationery	9.40	5.85	3.55			
Surety bond of Secretary	12.50		12.50			
Expenses of Special Comm.	2.18		2.18			
Branch Secretaries expenses	56.22		56.22			
Stenographic report	96.15		96.15			
Association badges	22.84		22.84			
Rental of safe deposit box	5.50	2.75	2.75			
Contribution to Biological Abstracts	50.00		50.00			
Purchase of typewriter	32.05	16.00	16.05			
Refunds	6.50	1.50		5.00		
Transfer to Permanent Fund from general cash	300.00		300.00			
Deposit of interest on exchange of bonds	47.48		47.48			
Federal check tax	.30	.15	.15			
Bank collection charges	4.20		4.20			
Purchase of back numbers	3.50	3.50				
Checks returned	67.14	50.64	16.50			
	$8,332.41	$7,260.77	$1,059.14	$ 7.50	$ 2.50	$ 2.50
Balance, Dec. 14, 1935	$7,514.87	$3,340.39	$2,921.08	$328.27	$163.51	$761.62

The balance is deposited as follows:

First National Bank of Amherst, checking account	$4,513.72
First National Bank of Amherst, savings department	3,000.00
Cash on hand	1.15
	$ 7,514.87

PERMANENT FUND AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the period from December 9, 1934 to December 14, 1935.

Balance, December 9, 1934			$15,896.70
Additions			
Interest from securities		$415.61	
Interest from savings deposits		197.18	
Gain from exchange of securities		47.48	
Transfer from Association account		300.00	960.27
Balance, December 14, 1935			$16,856.97
Invested as follows			
Par value	Securities		
3000	United States Treasury Bonds 2¼%	$2,984.00	
2500	United States Treasury Bonds 3¼%	2,484.00	
3000	United States Savings Bonds	3,750.00	
4000	Federal Land Bank of St. Louis 4¼%	3,550.00	
2000	Province of Ontario 5%	2,000.00	$14,768.00
Bank Deposits:			
Savings Bank			
Amherst Savings Bank		1,032.90	
Savings Department			
Franklin County Trust Co., Greenfield, Mass.		1,056.07	2,088.97
			$15,856.97

Robert C. Burdette, assistant entomologist of the New Jersey experiment station, died on January 6, 1935, at the age of 37 years. Born March 10, 1898, in Woodfield, Md. He received his college training in the University of Maryland and received his Doctor's degree from Rutgers. He served with distinction in the World War and upon its conclusion entered the service of the Bureau of Entomology. He resigned to join the staff of the New Jersey station in 1928. His duties in connection with the work of that station brought him into wide contact with the growers of the state, among whom he came to hold a high reputation. His loss is greatly felt and his passing mourned.

Charles H. Peet of the Rohm & Haas Company Inc. died suddenly on February 27, 1935, while attending a convention of insecticide manufacturers in New York. He was born October 12, 1892, in Jamestown, Mich. He graduated with high honors from Hope College in 1914 and received his Doctorate from the University of Illinois in 1922. He served during the war in France and held a lieutenancy in the Reserve Corps. His chief work was done while in the service of the Rohm & Haas Company, where he was instrumental in the development of the Peet-Grady method of testing household insecticides, which has become an officially recognized method. He made for himself a firm place in the esteem of his colleagues in the insecticide field and a host of personal friends. His passing is deeply mourned by friends and associates.

H. L. Fackler died on May 21, 1935, from a sudden heart attack at his home in Knoxville, Tenn. Mr. Fackler rendered conspicuous service as assistant state entomologist where his efforts in behalf of the nursery industry brought great benefit to that business. He was later connected with the Tennessee Agricultural Experiment Station, leaving to enter the service of the Louisville and Nashville Railroad where he rendered conspicuous service as agricultural development agent in developing the strawberry industry of the state. It was in this work that death overtook him. His death at the height of a useful career found many to mourn him.

COTTON STATES BRANCH

The 10th annual meeting of the Cotton States Branch was held at Atlanta, Ga., on January 31 and February 1 in conjunction with the annual convention of the Association of Southern Agricultural Workers. Chairman S. W. Bilsing presided. An important feature of the program was the symposium on the screw worm situation in the southeast. The meeting was honored by the presence of President L. A. Strong of the American Association of Economic Entomologists, who reported on some of the features of the Pittsburgh Meeting. Assistant Chief A. S. Hoyt and Dr. F. C. Bishopp of the Bureau of Entomology and Plant Quarantine were also present and contributed to the program. President Strong appointed Mr. M. S. Yoemans official representative of the Association for the meeting.

It was considered one of the most interesting and instructive meetings the Branch has held. The officers elected were:

Chairman, CLAY LYLE, State College, Miss.
Vice Chairman, R. C. GAINES, Tallulah, La.
Sec'y-Treas., O. I. SNAPP, Fort Valley, Ga. (*Continued in office.*)

PACIFIC SLOPE BRANCH

The 20th annual meeting of the Pacific Slope Branch was held at the University of California at Los Angeles, June 26–28, Vice Chairman Campbell presiding, owing to the illness of Chairman H. E. Burke. A program of papers was offered on the 26th and 27th and the morning session of the 28th. On the 29th many took the opportunity to visit the

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Audit of the accounts of the American Association of Economic Entomologists, covering period from December 9, 1934 to December 14, 1935.

Cash book record of receipts verified.

Cancelled checks compared with recorded payments and vouchers examined.

Cash book balance, as shown by this report, verified with statement from First National Bank of Amherst, Mass., and balance recorded in deposit book No. 2493 of Savings Department of the First National Bank of Amherst, Mass.

Cash in hands of treasurer verified.

Income from Permanent Fund and balance of December 14, 1935, verified by examination of bank books and securities.

Appended is a schedule of receipts and payments, for the period of this audit, showing balance in custody of the treasurer, December 14, 1935, and a statement of the income and addition to the Permanent Fund during the period and its present condition.

ERNEST L. MILLINGTON, *State Accountant*

Springfield, Mass.
December 14, 1935.

Citrus Experiment Station at Riverside. President Strong of the parent Association was the principal speaker of the banquet on the 27th. The total attendance was 108.

The following were elected:

Chairman, H. A. SCULLEN, Corvallis Ore.
Vice Chairman, A. L. STRAND, Bozeman, Mont.
Sec'y-Treas., J. F. LAMIMAN, Berkeley, Calif.

EASTERN BRANCH

The seventh annual meeting of the Eastern Branch was held at Baltimore, Md., November 14 and 15. Chairman B. A. Porter presided. The program was a very heavy one, approximately 60 papers being presented. The attendance was large and the subject matter of the papers so timely the interest was sustained throughout all the sessions. Dr. Ernest N. Cory was appointed by President Strong official delegate of the parent Association.

The officers elected were:

Chairman, PHILIP GARMAN, New Haven, Conn.
Vice Chairman, HARLAN N. WORTHLEY, State College, Pa.
Sec'y-Treas., H. B. WEISS, Trenton, N. J. (*Continued in office*).

INDICES TO THE LITERATURE OF AMERICAN ECONOMIC ENTOMOLOGY

Indices I and II.—Sales of these volumes in 1935 amounted to $26.

Index III.—Sales during the current year have reached $15.50.

Index IV.—Sales have amounted to $29.

Substantial reduction in prices of these volumes were made during the year by vote of the Association at the Pittsburgh meeting. It is hoped that sales during the coming year will be proportionally increased.

JOURNAL OF ECONOMIC ENTOMOLOGY

Volume 28 of the JOURNAL OF ECONOMIC ENTOMOLOGY has been completed with the December issue and contains 1092 pages. Because of the change to solid type, this represents a slight increase in the amount of subject matter included. This change has also meant a substantial increase in the cost of publication. This increase had to be absorbed during the current year, since the slight increase in subscription rates takes effect in 1936. It is hoped that with this added income the JOURNAL may substantially increase the amount of subject matter printed.

The present (December) subscription list consists of United States 1274, Canada and U. S. insular possessions 88, foreign 381—a total of 1743, as compared with 1720 from the same month of the previous year, a net gain of 23.

There is attached hereto a statement of the cash received and disbursements made by the JOURNAL, Association and Index accounts and also additions by interest, exchange of securities and other increment to the Permanent Fund. This has been audited by Ernest L. Millington, state accountant, Springfield, Mass. (See pp. 240, bottom 241.)

A. I. BOURNE, *Secretary*

It was regularly moved, seconded and carried that the report of the Secretary be adopted.

PRESIDENT STRONG: Next is the report of the Executive Committee.

RECOMMENDATIONS OF THE EXECUTIVE COMMITTEE

1. That $425 be transferred from the Association funds to the Permanent Fund.
2. That the Committee on Training of Entomologists be discontinued.
3. That the terms of the present members of the Committee on Advancement of Official Entomology be terminated and that there be elected three members with terms of one, two and three years, one member to be elected each succeeding year for a three-year term.
4. That the terms of the present members of the Committee on Popular Entomological Education be terminated and that there be elected three members with terms of one, two and three years, one member to be elected each succeeding year for a three-year term.
5. That there be established a standing Committee on Insecticide Terminology with five members to be elected with terms of one, two, three, four and five years, one member to be elected each succeeding year for a five-year term.

6. The Executive Committee recommends that the office of the Secretary and the office of the Business Manager be paid $200 each per annum, and the Secretary be allowed $100 for stenographic and office expense.

7. The Executive Committee proposes to undertake a study, and if necessary, a suggested revision of the Constitution and the By-Laws of the Association to involve considerations and recommendations to the Association on the following points and such other points as the membership may suggest.

(a) Branches and Sections, to include publications, dues and other organization features.

(b) Possibility of affiliation with existing organizations in allied fields.

(c) Subsidiary meetings.

(d) Affiliation and responsibility of the Association with respect to organizations which it has helped to sponsor.

8. In view of the congested condition likely to obtain in Washington, D. C., at the time the meetings of the American Association for the Advancement of Science will be held there in the winter of 1936–37, the Executive Committee recommends that this Association not meet in Washington, D. C., in the winter of 1936–37 and that place of the meeting be left to the Executive Committee, the place to be announced at the earliest possible date.

9. The Executive Committee understands, and so recommends, that if Article II, Section 4, of the By-Laws be amended as proposed in the program, that the term of the present members of the Advisory Committee be considered as terminated.

10. The Executive Committee recommends the following with respect to publication policies of the JOURNAL OF ECONOMIC ENTOMOLOGY:

With certain exceptions hereinafter noted, all papers accepted for publication in the JOURNAL shall be published in approximate order of their receipt by the editor. The editor may make changes in the order of publication that do not conflict with the purpose of this recommendation, which is to give all members of the Association equal opportunity to publish in the JOURNAL. When an author offers to pay the full cost of printing an acceptable article it shall be published in the next issue of the JOURNAL to be made up after the acceptance of the article. The date of receipt of each accepted article shall be published with the article. When an article is returned to the author for revision the date of receipt shall be the date on which the revised manuscript is received by the editor. With the exception of the annual address of the president of the Association, those of section chairman and invitation papers, each manuscript received for publication in the JOURNAL shall be sent by the editor to a member of the Advisory Committee best qualified to pass on it. The editor shall limit the time that the member of the committee can hold a manuscript. If the editor cannot get action from a committee member within the time limit, the editor shall pass on the manuscript himself. Rejection of a manuscript by the editor shall be final, but rejection by an advisory committee member can be overruled by the editor and one other member of the advisory committee.

LEE A. STRONG, *President of Association and Chairman of Executive Committee*

The motion to accept was regularly made, seconded and adopted.

PRESIDENT STRONG: The next is the report of the delegate to the International Congress of Entomology at Madrid, by Dr. O. A. Johannsen, of Ithaca, N. Y.

REPORT OF THE DELEGATE TO THE INTERNATIONAL CONGRESS OF ENTOMOLOGY AT MADRID

The Sixth International Congress of Entomology, under the presidency of Professor I. Bolivar Urrutia, was held in Madrid, Spain, September 6 to 12, 1935. Most of the meetings excepting those which took place at El Excorial on Sunday the 8th were held in the auditorium and lecture rooms of the Science Institutes at No. 119 rue de Serrano. At the first general meeting, after the opening speech by Professor Bolivar, an address of welcome was given by the President of Spain, followed by brief addresses by four members of the Congress in behalf of the delegates of the several governments. Over 400 members were in attendance, representing over 30 countries. Visitors from North America were few, there being but 15 present from the United States and seven from Canada. Four general sessions were held as well as a number of sections for general entomology, economic entomology, ecology, medical and veterinary entomology, forest entomology, anatomy and physiology, nomenclature and apiculture. The addresses were given in English, German, French and

Spanish. The committee in charge of arrangements added much to the pleasure of the visitors by providing excursions to the palace and gardens of the Aranjuez, to the palace and forest of El Pardo, to the cities of Toledo and Segovia, as well as a collecting trip to the biological station and the Valsain forest near Guadarrama. The reception of the President of the Republic at the National Palace and the banquet gave additional opportunity for the entomologists of various countries to become acquainted. At the business meeting Mr. N. D. Riley of the British Museum was added to the permanent executive committee.

The Seventh International Congress of Entomology will be held in Berlin, Germany, in the summer of 1938, under the presidency of Dr. Erich Martini, of the Institut für Schiffs und Tropenkrankheiten at Hamburg.

O. A. JOHANNSEN, *Delegate*

PRESIDENT STRONG: The next is the report of the Special Committee on Proposed Amendments to the Constitution, by Dr. P. W. Claassen. Since Dr. Claassen is not in the room at this time, we might take up the proposed amendments to the By-laws which follow the report of that committee, if that is not objectionable, and go back to this special report when Dr. Claassen comes in.

There is a proposed amendment to the By-laws, as follows: That Article II, Section 4, be amended to read as follows: "Section 4. The Publication of the JOURNAL OF ECONOMIC ENTOMOLOGY shall be entrusted to an Editor, an Associate Editor and a Business Manager, to be known as the Editorial Board, nominated by an Advisory Committee of ten members, which latter shall be elected for terms of five years so arranged that two shall be elected annually. The members of this Committee shall have an advisory relation to the above constituted Editorial Board."

The motion was regularly moved, seconded, put to a vote and carried.

PRESIDENT STRONG: In view of the fact that the Association has voted to approve the Executive Committee report, and with the adoption of this amendment the terms of the members of the present board are considered as being terminated, I am going to ask that the Nominating Committee bring in at this afternoon's sessions nominations for these ten members, so that the ten members may tomorrow afternoon bring in nominations in the regular way for editor, associate editor, and so on.

The next suggestion is that Article 3, Section 1, be amended to read as follows: "Section 1. The annual dues of members shall be two dollars, which shall be payable in advance. No dues shall be payable from foreign members. Annual dues shall not include subscription to the JOURNAL OF ECONOMIC ENTOMOLOGY."

My understanding with respect to that amendment is that the intention was that when the Index to Economic Entomology is ready to be printed, the members will buy the next issue of the index to the literature of economic entomology, but that following that, this fifty cents a year addition to the dues will pay for the next copy of the index for the members. I believe that is correct. What is your pleasure with respect to this proposed amendment?

Adoption of this proposed amendment was regularly moved, seconded and carried.

PRESIDENT STRONG: We will now hear the report of the Special Committee on Proposed Amendments to the Constitution, by Dr. P. W. Claassen.

REPORT OF THE SPECIAL COMMITTEE ON PROPOSED AMENDMENTS TO THE CONSTITUTION AND BY-LAWS

A year ago, the members of your committee recommended that the distinction between active and associate membership be abolished, and at that time they recommended that the constitution be amended so as to read that there shall be only active and foreign members. That proposal was adopted, and in accordance with the constitution a committee was appointed to study this problem and to submit to all active members a statement of the proposed changes. The members of this committee were Professor Harry S. Smith, J. I. Hambleton and myself.

About the tenth of November, we sent our notices to every active member of the Association, in which were stated the changes which would be necessary to abolish the distinction between active and associate membership. We asked those members who could not attend this meeting to send us, if possible, letters expressing their opinion regarding this change. I have here fifty-one letters received from various members who did not expect to be here, and of these fifty-one only one letter is opposed to this change. The other fifty are in favor of abolishing the distinction between active and associate membership.

I believe that any of the members here who have served on the Membership Committee will agree with me that it has been very difficult to determine when associate members should be transferred to active membership. In some parts of the country, the active members have been more active in pushing young entomologists for transfer from one to the other membership, and the committee is not in a position to be able to judge when these memberships should be transferred, so they have to rely largely on the recommendations that were made. In other instances, no recommendations have come to the committee, and the committee has been forced to canvass the membership, the associate membership, very carefully, to determine just what they should do. As the result, we feel that there has been considerable injustice done in the past, that there are still associate members who should have been active members for some years, and possibly in other instances associate members have been transferred to active membership much sooner than some of the other men who have been in the profession as long as they have or longer.

For that reason and others, the committee appointed by the president moves that the changes as given in the following notice be adopted.

The motion offered by the Membership Committee provides for an amendment to Article 2 of the constitution as follows:

"Article 2, Section 2, in the first sentence strike out the word 'associate' so that it shall read, The classes of membership shall be active and foreign.'

"Article 2, Section 3, which defines associate membership shall be deleted.

"Article 2, Section 4, shall become Section 3 without change.

"Article 2, Section 5, shall become Section 4 and the words 'associate and' be dropped so that it shall read 'Foreign members shall not be entitled to hold office or to vote.'

"Article 2, Section 6, shall become Section 5 without change.

"Article 2, Section 7, shall become Section 6, and the next to the last word 'other' shall be changed to 'active.'

"Article 2, Section 8, shall become Section 7 without change."

The motion was regularly moved, seconded and adopted.

PRESIDENT STRONG: Is the Nominating Committee prepared to report on the nominations for the Advisory Committee?

GEORGE A. DEAN: The report is as follows:

For one year	*For two years*	*For three years*	*For four years*	*For five years*
F. L. Thomas	G. M. List	Roger B. Friend	H. G. Crawford	S. A. Rohwer
E. N. Cory	W. A. Riley	J. S. Houser	Roger C. Smith	W. B. Herms

The motion that the report be approved was moved, seconded and adopted.

PRESIDENT STRONG: I would request that the members of the Advisory Committee just elected be prepared tomorrow afternoon to submit nominations for the editor, associate editor and business manager of the JOURNAL.

The meeting recessed at eleven-forty o'clock.

Tuesday Afternoon Session

December 31, 1935

The meeting convened at two o'clock with President Strong presiding.

President Strong announced the names of the Advisory Committee elected in the Tuesday morning session and since no chairman was elected for the Advisory Committee appointed Dr. Herms as the temporary chairman.

Wednesday Afternoon Session

January 1, 1936

PRESIDENT STRONG: We come now to the final business session, and before taking up the first report I want to take a moment to thank those who helped during the past year in the affairs of the Association, those who have helped as members of committees during this session and those who have taken part in the program.

The first report is that of the Committee on Resolutions.

REPORT OF THE COMMITTEE ON RESOLUTIONS

(1) *Be it Resolved* that the Association express through its Secretary appreciation of the admirable arrangements made by the local committee and the Association officers for the convenience of attending members and the facilities for meetings, and express grateful appreciation to the local committee for the pleasurable entertainment at the entomologists' dinner, and that thanks be extended to the hotel management for courtesies accorded to our membership.

(2) *Be it Resolved* that the Association express its thanks to Drs. Van Dine, Keitt and Auchter, for their fine contribution to the symposium of this program.

(3) *Be it Resolved* that this Association express its belief in the timeliness and wisdom of efforts now being made and plans under way to bring about a closer bond among all workers in entomology, looking forward to the time when all of the various activities, societies, branches and interests may be so related in organization work and publications as to constitute a substantial unity of aim and effort.

(4) *Be it Resolved* that because of the increasing use of airplanes in the application of insecticides in large scale operations, sometimes in regions of diversified farming operations, entomologists are obligated to exercise adequate precautions to avoid a menace to bee keeping, animal industry or other proper pursuits, and that in addition are under obligation to use their influence to prevent unwarranted practices on the part of commercial airplane service organizations.

(5) *Be it Resolved* that the American Association of Economic Entomologists, at its annual meeting in St. Louis, strongly commends the program now in effect by the Bureau of Entomology and Plant Quarantine for the eradication of the Dutch elm disease, and strongly recommends that sufficient federal appropriation be made available for the continuation of this work. It is also recommended that a copy of this resolution be sent to the Secretary of Agriculture.

W. B. HERMS, *Chairman*
C. J. DRAKE
W. C. O'KANE
J. G. SANDERS
CLAY LYLE

The resolutions were moved, seconded and adopted en bloc.

PRESIDENT STRONG: The next report is that of the chairman of the Committee on Membership, Dr. P. W. Claassen.

REPORT OF THE COMMITTEE ON MEMBERSHIP

The Membership Committee recommends the election of 49 persons to active and one to foreign membership, as follows:

ACTIVE MEMBERS

Anderson, O. G.
Andre, Floyd
Becker, Wm. B.
Ben-Amotx, Yehiam
Berry, N. O.
Biron, Raphael A.
Blazzard, John E.
Brayton, Bert O.
Brown, Cary T.
Burgess, Robert W.
Bussart, J. Everett
Chiu, Shin Foon
Courtney, O. K.
Craig, Roderick
Cupples, Homer L.
Dahms, Reynold C.
Dibble, C. B.
Drage, Chas. M.
Ellisor, L. C.
Falls, Olive
Farstad, Chris. W.
Ferris, Curtis A., Jr.
Fisher, Robert A.
Freitag, Julius H.
Gibson, K. E.
Gillies, Kenneth D. J.
Granett, Philip
Grout, Roy A.
Gunderson, Harold
Gunnell, Farrell H.
Hall, Bernarr J.
Haller, H. O.
Hansberry, Roy
Hauke, Harold A.
Hawkins, Lon A.
Heal, Ralph Edward
Heaton, Robert R.
Jeancon Harold M.
Jobbins, Daniel Manley
Le Veque, Miss Norma
Lincoln, Chas G.
Lindquist, Arthur W.
Linsley, E. Gorton
Partlow, Chas. O.
Persing, Chas. O.
Pletsch, Donald J.
Reppert, R. R.
Ritcher, Paul O.
Soraci, Frank A.
Smith, Cass F.
Smith, Carroll N.
Smith, Gordon L.
Smith, Lloyd E.
Troth, Merle S.
Uichanco, L. B.
Wampler, Elvin L.
Whall, Harry H.
Worthington, A. D.
Yeager, J. Franklin

FOREIGN MEMBERSHIP

Minkiewicz, Stanislau

The following are recommended for reinstatement:

Hixson, Homer
Wood, W. B.

Resignations are as follows:

Bailey, L. L.
Deen, R. B.
Hollway, T. E.
Lott, Earl
Parker, J. B.
Travis, B. V.
Winchester, H. I.

DECEASED

Burdette, Robert C.
Peet, Charles H.
Fackler, H. L.
Hinds, W. E.

Acceptance of the Membership Committee report was regularly moved, seconded and approved.

PRESIDENT STRONG: The next item of business is nomination of JOURNAL officers by the Advisory Committee. I believe Dr. Herms is chairman of that committee.

W. B. HERMS: Mr. President and Gentlemen: At the organization meeting yesterday the speaker was elected Chairman of the Advisory Committee and in that capacity wishes to make the following report and nominations:

REPORT OF THE ADVISORY COMMITTEE

For many years the JOURNAL OF ECONOMIC ENTOMOLOGY has been most ably edited by the present editor, who has built into that JOURNAL a reputation of great worth. The JOURNAL OF ECONOMIC ENTOMOLOGY stands as a worthy memorial to the untiring efforts of one of our best beloved entomologists. From the early stages of its development, with constant nurture, that editor has reared our JOURNAL, nursed it as only a loving father could nurse his very child, reared it to its present stature and high position among scientific journals of the world. Through storm and stress, fair weather and foul, superimposed

upon his own duties upon our behalf, that editor has given of his valuable time freely and cheerfully. It is high time that his Association recognize this contribution on the part of Dr. E. P. Felt. He has long prayed that he be relieved, and now your committee recommends that this request be granted, that he be relieved of his duties as active editor of the JOURNAL OF ECONOMIC ENTOMOLOGY, and we do now nominate Dr. E. P. Felt as Honorary Editor, and ask that his name appear as such on the pages of that JOURNAL. Secondly, we nominate as editor Dr. T. H. Frison of Urbana, Ill. We make this nomination with confidence and satisfaction. Third, as associate editor, we are pleased to nominate Mr. H. B. Weiss, New Brunswick, N. J. Fourth, as business manager we nominate the Secretary-elect of the Association, Dr. E. N. Cory.

It was regularly moved, seconded and carried that the Secretary cast the unanimous ballot of the Association for these officers.

W. B. HERMS: Mr. President, I move that this Association extend a rising vote of thanks to Dr. E. P. Felt for the magnificent work that he has done for this organization.

The members arose and applauded.

PRESIDENT STRONG: Next is the report by the chairman of the Committee on Nominations, Professor George A. Dean.

GEORGE A. DEAN: Mr. President and Members of the Association: I might state that one member of this Nomination Committee has not been present, Mr. H. G. Crawford of Canada, but Mr. Crawford did send in his full slate of nominations, which the two members present have taken into consideration.

REPORT OF THE COMMITTEE ON NOMINATIONS

I shall first read the nominations of the standing committees:

The Executive Committee: for three years, L. A. Strong; for two years, T. J. Headlee.

Committee on Membership: for three years, W. P. Flint.

The members nominated for the Advisory Committee, ten of them, were acted on yesterday.

Committee on Insect Collections: for three years, E. C. Van Dyke and W. J. Brown.

Committee on Research Work on the Control of the European Corn Borer: for five years, also Chairman, J. J. Davis.

Board of Trustees for Permanent Fund: for three years, A. F. Burgess.

Trustees for Crop Protection Institute: for three years, W. C. O'Kane.

Committee to Formulate Plans for Investigations of the Codling Moth from Biologic and Control Standpoints: for three years, P. J. Parrott and W. A. Ross.

Committee on Insecticide Terminology: for one year, G. L. Hockenyos; for two years, M. D. Farrar; for three years, R. H. Robinson; for four years, William Moore; for five years, C. M. Smith, Chairman.

Committee on Advancement of Official Entomology: for three years, E. P. Phillips, Chairman; for two years, T. J. Headlee; for one year, W. P. Flint.

Committee on Popular Entomological Education: for three years; J. A. Hyslop, Chairman; for two years, E. O. Essig; for one year, J. J. Davis.

The Vice Presidents are nominated, and elected, as a matter of fact, by their respective branches or sections.

Chairman of the Pacific Slope Branch, H. A. Scullen; Cotton States Branch, Clay Lyle; Eastern States Branch, Philip Garman; Section of Plant Quarantine and Inspection, M. S. Yeomans; Section of Apiculture, W. J. Nolan; Section of Extension, R. R. Reppert.

Secretary, E. N. Cory.

First Vice President, G. M. Bentley.

President, L. S. McLaine.

It was regularly moved, seconded and adopted that the Secretary cast the unanimous ballot for the Association for the election of these nominations.

PRESIDENT STRONG: I will ask Past Presidents Phillips and Ruggles to escort Leonard S. McLaine to the chair.

Past Presidents Phillips and Ruggles escorted President-elect McLaine to the chair.

PRESIDENT STRONG: Dr. McLaine, I congratulate you, and since the Association has been more or less without a president for a full year I congratulate them. I turn over to you this gavel with the full confidence that the Association affairs will be well conducted, and that you will get a great deal of enjoyment out of the work.

President-elect McLaine took the chair.

PRESIDENT MCLAINE: Mr. Strong and members of the Association: I can assure you I have had a great many shocks in my life, and I never had a greater one than I got this afternoon. I was very appreciative, however, of Mr. Strong's thoughtfulness in selecting two such able and weighty past presidents to conduct me to this honor, this post. Otherwise I feel that I never would have made the grade, so to speak.

Gentlemen, I feel that you have entrusted confidence in placing me in this position. I cannot say anything further. I have not had a chance to collect my thoughts or my wits, but I can assure you that I will do everything that is within my power to further the interests of the Association during the next year.

We will now proceed with the program. Next is miscellaneous business.

W. P. FLINT: In view of the fact that the papers which have been read today have pertained mainly to insecticides, and are papers which most of us would want to see in print as soon as possible, I should like to suggest that these papers be included in the February issue of the JOURNAL.

PRESIDENT MCLAINE: Do you wish to make a motion?

W. P. FLINT: I would just like to make the suggestion.

E. P. FELT: I am willing to take a chance to make that as a motion. It may be lost.

W. P. FLINT: I second the motion.

PRESIDENT MCLAINE: It is moved by Dr. Felt and seconded by Mr. Flint that the papers that have been presented on this symposium on insecticides be included in the February issue of the JOURNAL.

J. A. HYSLOP: I believe that we have adopted a plan of publication which allows date of receipt of manuscripts to give precedence in the JOURNAL OF ECONOMIC ENTOMOLOGY. Was it the thought that the papers on the program should appear in their order? I do not know what the thought was in that matter. We certainly would not want to go against something we have just adopted.

E. P. FELT: Mr. President, I am very well aware that the action has been taken and I have a notion that those who favor that action do not know just what it would mean if it were applied literally. If the papers are to be published strictly according to the date of publication it means that in all probability no papers in the proceedings of this meeting, except the address of the President, the addresses of the secretaries of the sections and the invitation addresses can be published until June or

August. If that is what the Association wants that is entirely all right with me, but as ex-editor I have enough matter on hand which would probably meet with the approval of the Advisory Committee to fill two and possibly three numbers.

My notion in regard to the JOURNAL is that it is to tender service to the members of the Association and in the case of these papers on insecticides it seems to me that they might have a very important influence on the work of the coming season. I am making that explanation.

F. LESLIE CAMPBELL: I noticed that nothing was said about the date on which the plan was to become effective. It seems to me that that might be decided at this time and Dr. Felt's motion is perfectly in order since that date was not decided. I recommended that it be put off until 1937 so that the change would not be too abrupt.

E. P. FELT: I had forgotten that, Dr. Campbell.

PRESIDENT MCLAINE: Is there any further discussion? Are you ready for the question? It has been moved and seconded that these insecticide papers be included in the February issue of the JOURNAL.

The motion was put to a vote and carried.

PRESIDENT MCLAINE: Is there any other business?

J. A. HYSLOP: I should like to ask the Association's permission, or ask the Association, to consider a motion on changing the name of the permanent Committee on Nomenclature to the Committee on Common Names. Our committee is constantly sent letters from entomologists asking us to do things which we have no authority to do and the name of the committee is a misnomer. Therefore, if it is in order, I would move that the name of the permanent Committee on Nomenclature be designated as the Committee on Common Names.

PRESIDENT MCLAINE: That is a substitution of the name?

J. A. HYSLOP: Yes.

C. L. METCALF: I second the motion.

A. F. BURGESS: I should like to suggest that it be the Committee on Common Names of Insects, and I might say that that Committee was originally called by that name but the term was changed to the Committee on Nomenclature some years ago. I think Common Names of Insects is much more distinctive and appropriate.

J. A. HYSLOP: I accept that suggestion.

C. L. METCALF: As the seconder, I accept it.

PRESIDENT MCLAINE: It is moved and seconded that the name of the permanent Committee on Nomenclature be changed to the Committee on Common Names of Insects.

The motion was put to a vote and carried.

C. H. HADLEY: I believe it has been more or less customary that this annual meeting send a telegram of greeting to Dr. L. O. Howard. I do not know whether the retiring President and Secretary have done that. If not, I should like to make a motion that such a telegram be sent, with the best wishes of the Association.

The motion was regularly moved, seconded and adopted.

PRESIDENT MCLAINE: Is there any other business? The next item is the fixing of the time and place of the next annual meeting.

L. A. STRONG: Mr. Chairman, that particular matter was taken care of, I believe, in the report of the Executive Committee wherein the Association voted to leave the selection of the place to the Executive Committee, but not to meet in Washington, D. C., in the winter of 1936–37.

PRESIDENT MCLAINE: Is there any other business to come before the Association? If not a motion to adjourn will be entertained.

The motion was so moved, seconded and carried and the meeting adjourned at four-ten o'clock.

SECTION OF PLANT QUARANTINE AND INSPECTION

Monday morning session, December 30, 1935.

The meeting of the Section of Plant Quarantine and Inspection of the American Association of Economic Entomologists convened at 9:30 a.m., December 30, in the Gold room of the Jefferson hotel in St. Louis, Mo. Dr. S. B. Fracker, chairman of the section, presided. More than 100 members were registered, representing 34 states, the Dominion of Canada and Mexico.

The chairman appointed the following committees:

Resolution: Carl J. Drake, chairman; F. N. Wallace.

Nominations: C. H. Hadley, chairman; L. S. McLaine, Geo. A. Dean.

The officers elected for the ensuing year were M. S. Yeomans, Atlanta, Ga., chairman, and E. L. Chambers, Madison, Wis., secretary.

The following resolution was passed:

WHEREAS, there is need of more uniformity in the inspection and certification of nursery stock,

Be It Resolved that the Section of Plant Quarantine and Inspection request the National Plant Board and the Bureau of Entomology and Plant Quarantine to develop and submit a plant inspection program to the several regional plant boards for their consideration.

Be It Resolved that the Section of Plant Quarantine and Inspection express its appreciation to the local committee on arrangements and accommodations.

SECTION OF EXTENSION

Monday evening session, December 30, 1935.

The meeting of the Section of Extension of the American Association of Economic Entomology convened at 7:30 p.m., December 30, in the Crystal room of the Jefferson hotel in St. Louis, Mo. E. G. Kelley, chairman of the section, presided and George D. Jones acted as secretary. The attendance at the session and the interest shown throughout the meeting was very good.

The chairman appointed the following committees:

Resolutions: Sam C. McCampbell, Charles E. Palm and R. R. Reppert.

Nominations: C. F. Stiles and Clay Lyle.

The Committee on Nominations recommended, and the section elected for 1936, as chairman R. R. Reppert, and A. D. Worthington as secretary.

The following resolutions were adopted:

WHEREAS, the Extension Division of the American Association of Economic Entomologists, in its meeting in the Jefferson hotel at St. Louis, Mo., on Monday evening, December 30, 1935, enjoyed to the utmost the proceedings of that meeting, and

WHEREAS, the comfort and convenience of the room assigned contributed not a small part to the success of that meeting,

Be It Resolved that we heartily express our appreciation to the parent organization of the American Association of Economic Entomologists for its services in arranging for, and to the management of the Jefferson hotel, in providing those accommodations.

Be It Further Resolved that our chairman, Mr. E. G. Kelley and our secretary, Mr. George D. Jones, be commended for their efforts in arranging the program and for the excellent manner in which this program was executed.

WHEREAS, in his administration of an entomological program from Washington, Mr. M. P. Jones has diligently applied himself to our various state problems and has contributed immensely to whatever success has attended our individual programs,

Be It Resolved that we express our appreciation of those services, in asking that these be continued throughout the coming year.

WHEREAS, all those in attendance were greatly inspired by the interesting information and advice presented by Mr. A. B. Graham, subject matter specialist of the Extension Service, Washington, D. C.,

Be It Resolved that the sincere thanks for the part he contributed be expressed to Mr. Graham, and that he be urged in whatever way possible, by personal contact or written word, and that we further express to him the hope that we may from time to time throughout the year, in whatever way possible, whether by personal contact or written word, continue to feel his inspirational influence.

Be It Further Resolved that these resolutions be spread upon the minutes of our organization and that the secretary be instructed to send copies of the secretary of the American Association of Economic Entomologists, the managers of the Jefferson hotel of St. Louis, Mo., Mr. E. G. Kelley, of Manhattan, Kan., Mr. George D. Jones, of Columbia, Mo., and Mr. M. P. Jones and Mr. A. B. Graham, of Washington, D. C.

SECTION OF APICULTURE

Monday afternoon session, December 30, 1935.

The meeting of the Section of Apiculture convened at 2:30 p.m. in the Crystal room of the Jefferson hotel at St. Louis, Mo., December 30. George H. Rea presided as chairman.

The officers elected for the ensuing year are W. J. Nolan, chairman, and W. A. Price, secretary.

PROCEEDINGS OF THE SEVENTH ANNUAL MEETING OF THE EASTERN BRANCH OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Held at the Southern Hotel, Baltimore, Md.,
November 14 and 15, 1935

The meeting was called to order by Chairman B. A. Porter. Mr. Lee A. Strong, Chief of the federal Bureau of Entomology and Plant Quarantine, spoke favorably of the way in which entomological work was progressing in the country at large in spite of the depression. His bureau has an allotment of approximately 25 millions of dollars from various emergency sources for entomological work of diverse kinds and full advantage is being taken of such opportunities to add to existing entomological knowledge.

Dr. L. O. Howard expressed his pleasure at being present and this was fully reciprocated by everyone in attendance.

FIRST BUSINESS SESSION, THURSDAY

November 14, 1935, 12-30 P.M.

The Chairman appointed the following committees:

Committee on Nominations, C. H. Hadley, L. A. Stearns, L. M. Peairs.

Auditing Committee, H. N. Worthley, Byrley F. Driggers.

Committee on Resolutions, E. N. Corry, P. J. Chapman, W. S. Hough.

The following report of the Secretary-Treasurer was read and referred to the Auditing Committee:

REPORT OF THE SECRETARY-TREASURER

Eastern Branch—American Association of Economic Entomologists.

The number of paying members of the Eastern Branch amounted to 92 in 1934. The following table shows the paid membership for the past six years:

State	1929	1930	1931	1932	1933	1934
West Virginia	1	1	1	2	2	2
Virginia	5	4	8	5	4	5
District of Columbia	6	3	9	2	5	6
Maryland	5	6	9	3	4	5
Delaware	2	2	3	1	2	5
Pennsylvania	9	3	11	5	15	13
New Jersey	26	21	19	11	23	20
New York	27	28	39	25	23	25
Connecticut	10	9	15	5	6	7
Rhode Island	2		1			
Massachusetts	6	5	14	8	4	3
Vermont	1	1				
New Hampshire			1	1		
Maine		1	2	1		1
Canadian Provinces	1					
Total	101	84	132	69	88	92

At our 1934 meeting, held in New York City, at the Hotel McAlpin, twenty-six papers were presented and printed in the Journal of Economic Entomology for 1935.

FINANCIAL STATEMENT

Balance on hand November 15, 1934		$89.35
Receipts		
Additional dues for 1934	$124.00	
Sale of space in 1934 program	180.00	
Receipts due to sale of directory space, listings and directories	1,770.40	
Dues for 1935 (to November 1)	74.00	2,148.40
		$2,237.75
Disbursements		
Lantern and operator, 2 days, Hotel McAlpin, 1934	$ 20.00	
Stenographic services in connection with directory	111.70	
Mimeographing in connection with directory	18.79	
Printing directory, bill heads, notices, etc.	611.35	
Stamps, directory, mailing permit	75.00	
Clerical services, Eastern Branch	20.00	
Postage, Eastern Branch	26.00	
Stationery, Eastern Branch	6.50	
Printing of proceedings ($73.00 balance due for 1933 proceedings; $66.00 for 1934 proceedings)	139.00	
Expenses of Secretary	11.67	
Refund of an overpayment	41.55	
Miscellaneous expenses, Tax on checks, etc.	2.24	
Total disbursements		$1,083.80
Balance on hand November 6, 1933 (Deposited in Trenton Trust Co.)		1,153.95
Accounts Receivable		
To be collected for advertising in directory		103.00

HARRY B. WEISS, Secretary-Treasurer

The following report of the Finance Committee was adopted.

REPORT OF THE FINANCE COMMITTEE

The Finance Committee met several times since the last Annual Meeting of the Association. They completed, we believe successfully, the publication of "*Entoma*, A Directory of Insect Pest Control." This was published late in June 1935, 3000 copies being printed at a cost of approximately $875. This includes the stenographic help or other help in getting the material ready, the printing of the directory prospectus, mail permit, postage incidental to getting the directory ready, solicitations for advertisements and mailing out the copies of *Entoma* sent to members of the American Association of Economic Entomologists and to members of the Eastern Branch. This gives a cost of approximately 26¢ per copy for the 3000 copies printed.

The receipts due to the sale of the directory advertising, listings, etc., amounted to $1,770.40 on November 1, expenses $873.09, leaving a profit of $897.31. There are some receipts and disbursements which have probably not been included in the above amount. Many single copies of the directory were paid for in stamps and these stamps were used in sending out other copies of the directory or in correspondence pertaining to the directory.

Data pertaining to the directory is as follows:

Number of one page advertisements	20
Number of half page advertisements	24
Number of quarter page advertisements	6
Number of paid listings	82
Number of companies taking listings	38
Number of companies taking paid advertisements	50
Number of pages in the directory	104
Copies of directory sold, approximately	200
Copies mailed free, approximately	1480
Copies on hand	1320

We wish to express our appreciation to Mr. R. J. Sim of the State Department of Agriculture, Trenton, N. J., for designing the first cover page.

Many letters of appreciation concerning Entoma have been received from various entomologists, commercial firms and others interested in insect pest control. A few companies have expressed their desire to be included among the advertisers in the next issue. It is believed that the next issue can be made bigger and better.

This report is respectfully submitted by the committee.

C. C. HAMILTON
E. E. BADERTSCHER
J. L. KING
J. L. HORSFALL
B. A. PORTER
A. WEED
H. B. WEISS

Mr. Ralph E. Heal, Department of Entomology, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey, was elected to affiliated membership.

FINAL BUSINESS SESSION

November 15, 1935, 12:30 P.M.

Chairman Porter called for reports of the following committees. These reports were all adopted by the Branch.

REPORT OF NOMINATING COMMITTEE

For Chairman, Philip Garman
For Vice Chairman, H. N. Worthley

C. H. HADLEY
L. A. STEARNS
L. M. PEAIRS

REPORT OF AUDITING COMMITTEE

We have audited the books of the Secretary-Treasurer and have found them to be correct and to agree with his financial statement.

H. N. WORTHLEY
B. F. DRIGGERS

Following the adoption of the above report, the report of the Secretary-Treasurer was accepted.

REPORT OF COMMITTEE ON RESOLUTIONS

WHEREAS, The Financial Committee has performed a splendid service for this Branch, especially in connection with the publication of *Entoma*.

Be it Resolved that the thanks of the Association be extended to the Committee and that the Committee be continued without change.

WHEREAS, Our Secretary-Treasurer has carried this Association through exceedingly trying financial difficulties with marked success,

Be it Resolved that the thanks of the Branch be tendered to Mr. Weiss.

WHEREAS, The fight for control of the Dutch elm disease seems to have reached a critical stage, and

WHEREAS, Adequate support, through direct appropriations, to the Bureau of Entomology and Plant Quarantine is necessary, especially for the early determination of the present incidence of the disease,

Be it Resolved that the Eastern Branch of the American Association of Economic Entomologists recommend that the American Association of Economic Entomologists seek the cooperation of the Phytopathologists in the formation of a committee on the Dutch elm disease, such committee to be directed and empowered to aid in securing adequate appropriations and in advancing the work in any practicable way.

WHEREAS, There is no official ruling governing the place of meeting of this Branch, and

WHEREAS, Individual members are likely to favor a meeting place nearest their homes and no one place is likely to meet the approval of all members,

Now, therefore, *Be it Resolved* that as a general policy, future meetings be held in rotation in the following cities: New York, Philadelphia and Baltimore, with New York as the place for the 1936 meeting.

Be it Resolved that the thanks of the Eastern Branch be extended to the local committee for their efforts and to the hotel management for the arrangements for the meetings and the comfort of the members.

E. N. Cory
P. J. Chapman
W. S Hough

The time of the next meeting was left to the Executive Committee with the understanding that the members should be notified by July 1, 1936.

During the first day of the sessions, the attendance was approximately 200. The following members and guests registered during the sessions:

Abbott, W. S.
Acree, Fred, Jr.
Adams, J. M. R.
Anthony, M. V.
Back, E. A.
Badertscher, A. Edison
Bailey, Harold L.
Becker, Geo. G.
Beckwith, Charles S.
Beinhart, E. G.
Billings, S. C.
Birdsall, R. W.
Blauvelt, W. E.
Bobb, M. L.
Bousquet, E. W.
Boyd, William
Bromley, Stanley W.
Brunson, M. H.
Buchanan, W. D.
Buchholz, A. B.
Burnside, C. E.
Busbey, Ruth L.
Caffrey, D. J.
Campbell, F. L.
Carruth, L. A.
Carter, R. H.
Chapman, P. J.
Cogswell, Robert A.
Collins, C. W.
Cory, Ernest N.
Craig, F. Waldo
Crossman, S. S.
Dearborn, F. E.
Dickinson, William
Dills, L. E.
Dirks, C. O.
Driggers, Byrley F.
Dye, H. W.
Faber, Henry B.
Felt, E. P.
Fenton, Alfred
Filmer, Robert S.
Fleming, Walter E.
Flenner, A. L.
Flint, W. P.
Frame, A. P.
French, G. T.
Friend, R. B.
Frost, S. W.
Gambrell, F. L.
Gardner, T. R.
Garman, Philip
Geissler, G. H.
Gertler, S J.
Gemmell, L. G.
Ginsburg, J. M.
Gooden, Ernest L.
Gould, Edwin
Granett, J.
Grayson, J. M.
Guy, H. G.
Gwin, C. M.
Hadley, C. H.
Haller, H. L.
Hallock, Harold C.
Hamilton, C. C.
Hammer, O. H.
Harms, Henry G.
Hartzell, Albert
Hatcher, R. F.
Heal, Ralph E
Hervey, G. E. R.
Hoffman, C. H.
Hooker, William H.
Horsfall, J. L.
Hough, W. S.
Huckett, H. C.
Hutson, Ray
Jefferson, R. N.
Jobbins, D. M.
Jones, Howard A.
Jones, M. P.
King, J. L.
Latham, C. G.
Lathrop, F. H.
Leonard, M. D.
Lipp, J. W.
Livingstone, E. M.
Longford, Geo. S.
MacCreary, Donald
Markwood, L. N.
Martin, Chas. H.
Maughan, Frank B.
McConnell, H. S.
Maxwell, Kenneth E.
Metzger, F. W.
Middleton, William
Moore, Joseph B.
Moore, Warren
Moore, William
Munger, F.
Murphy, D. F.
Nelson, R. H.
O'Kane, William H.
Pearson, A. M.
Pierce, W. Dwight
Plumb, G. H.
Poos, F. W.
Ranck, W. A.
Readio, Philip A.
Reed, T. W.
Reed, W. D.
Retzer, Robert, Jr.
Reynolds, G. D.
Richmond, E. Avery
Roark, R. C.
Sanders, J. G.
Sanford, H. L.
Salzberg, P. L.
Savidge, W. N.
Schoene, W. J.
Sherman, Ralph W.
Siegler, E. H.
Smith, Charles F.
Smith, C. M.
Smith, Floyd F.
Smith, Z. E.
Spies, Joseph R.
Spessard, L. L.
Stearns, L. A.
Stene, A. E.
Stockwell, C. W.

Strong, Lee A.
Sullivan, W. N.
Swaine, J. W.
Thomas, C. A.
Thompson, Friar, Jr.
Tischler, Nathaniel
Turner, Neely
Van Dine, D. L.
Vivian, D. L.
Vreeland, C. D.
Walker, Harry G.
Weed, Alfred
Weiss, H. B.
Whitman, R. C.
Whitten, R. R.
Wolfenbarger, D. O.
Wood, W. B.
Woodside, A. M.
Worthley, H. N.
Worthley, L. H.
Yetter, W. P.
Zappe, M. P.

REPORT OF THE DELEGATE TO THE FOURTEENTH ANNUAL MEETING OF THE NORTH CENTRAL STATES ENTOMOLOGISTS

The 14th meeting of the North Central States Entomologists was held at Urbana, Illinois, February 28 to March 1, 1935. One hundred forty-five entomologists representing 24 states and the District of Columbia were present.

In keeping with the practice established at the first North Central States Entomologists meeting, no papers were presented. Instead various topics were discussed by one or more leaders who had been designated in advance of the meeting. Fifty separate topics were discussed, these having been selected from a large group of suggested topics submitted by the entomologists from the various states making up this group. The interest in the meeting was excellent, with many very interesting discussions. An eighty-page mimeographed report of the meeting has been prepared by the Illinois Natural History Survey and the State experiment station.

It was voted to hold the next meeting at Ames, Iowa. The organization will be continued, as in the past, without dues, without officers, and without the presentation of papers. While all of the foregoing may seem necessary to the continuance of such an organization, the best proof that they are not essential is the fact that the North Central States Entomologists group have continued their meetings for fourteen years with an increasing interest and attendance every year.

W. P. Flint, Urbana, Ill

OFFICIAL ROSTER

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

[Organized 1889, Incorporated Dec. 29, 1913]

OFFICERS, 1936

Leonard S. McLaine	G. M. Bentley	Ernest N. Cory
Ottawa, Canada	Knoxville, Tenn.	College Park, Md.
President	*First vice president*	*Secretary*

VICE PRESIDENTS

H. A. Scullen, Corvallis, Ore. (Pacific Slope Branch)
Clay Lyle, State College, Miss. (Cotton States Branch)
Philip Garman, New Haven, Conn. (Eastern States Branch)
M. S. Yeomans, Atlanta, Ga. (Plant Quarantine & Inspection)
W. J. Nolan, Washington, D. C. (Apiculture)
R. R. Reppert, College Station, Tex. (Extension)

BRANCH AND SECTION SECRETARIES

J. F. Lamiman, Davis, Calif. (Pacific Slope Branch)
Oliver I. Snapp, Fort Valley, Ga. (Cotton States Branch)
H. B. Weiss, Trenton, N. J. (Eastern States Branch)
E. L. Chambers, Madison, Wis. (Plant Quarantine & Inspection)
W. A. Price, Lexington, Ky. (Apiculture)
A. D. Worthington, Ames, Iowa. (Extension)

STANDING COMMITTEES

Executive Committee—LEONARD S. MCLAINE, Ottawa, Canada, *Chairman. Ex-officio.*

A. F. BURGESS, Greenfield, Mass. Term expires 1936.
ERNEST N. COREY, College Park, Md. *Ex officio.*
T. J. HEADLEE, New Brunswick, N. J. Term expires 1937.
J. R. PARKER, Boseman, Mont. Term expires 1937.
E. F. PHILLIPS, Ithaca, N. Y. Term expires 1936.
L. A. STRONG, Washington, D. C. Term expires 1938.

Committee on Common Names of Insects.—J. A. HYSLOP, Washington, D. C., *Chairman.*

F. C. BISHOPP, Washington, D. C.
H. G. CRAWFORD, Ottawa, Canada.
E. O. ESSIG, Berkeley, Calif.
H. B. HUNGERFORD, Lawrence, Kan.

Committee on Membership.—C. H. RICHARDSON, Ames, Iowa, *Chairman.*

W. P. FLINT, Urbana, Ill. Term expires 1936.
WILLIAM MOORE, New York, N. Y. Term expires 1937.

Advisory Committee, Journal of Economic Entomology.—W. B. HERMS, Berkeley, Calif. *Chairman.* Term expires 1940.

ERNEST N. CORY, College Park, Md. Term expires 1936.
H. G. CRAWFORD, Ottawa, Can. Term expires 1939.
ROGER B. FRIEND, New Haven, Conn. Term expires 1938.
J. S. HOUSER, Wooster, Ohio. Term expires 1938.
G. M. LIST, Fort Collins, Colo. Term expires 1937.
W. A. RILEY, St. Paul, Minn. Term expires 1937.
S. A. ROHWER, Washington, D. C. Term expires 1940.
ROGER C. SMITH, Manhattan, Kan. Term expires 1939.
F. L. THOMAS, College Station, Tex. Term expires 1936.

Joint Committee on Insect Collections.—T. H. FRISON, Urbana, Ill., *Chairman.* Term expires 1936.

W. J. BROWN, Ottawa, Canada. Term expires 1938.
H. H. KNIGHT, Ames, Iowa. Term expires 1937.
FRANK E. LUTZ, New York, N. Y. Term expires 1937.
C. F. W. MUESEBECK, Washington, D. C. Term expires 1936.
E. C. VAN DYKE, Berkeley, Calif. Term expires 1938.

Committee on Research Work on Control of the European Corn Borer—J. J. DAVIS Lafayette, Ind., *Chairman.* Term expires 1940.

A. B. BAIRD, Belleville, Ont., Canda. Term expires 1939.
LAWSON CAESAR, Guelph, Ont., Canada. Term expires 1936.
D. F. CAFFREY, Washington, D. C. Term expires 1937.
G. A. DEAN, Manhattan, Kan. Term expires 1938.

Board of Trustees for Permanent Fund—ERNEST N. CORY. College Park, Md., *Chairman. Ex officio.*

A. F. BURGESS, Greenfield, Mass. Term expires 1938.
LEONARD S. MCLAINE, Ottawa, Canada. Term expires 1937.
P. J. PARROTT, Geneva, N. Y. Term expires 1936.

Representative to National Research Council.—S. A. ROHWER, Washington, D. C. Term expires 1937.

R. W. LEIBY, Raleigh, N. C., *Alternate.* Term expires 1937.

Councillors for the American Association for the Advancement of Science.

G. M. BENTLEY, Knoxville, Tenn. Term expires 1936.
ALVAH PETERSON, Columbus, Ohio. Term expires 1937.

Trustees for Crop Protection Institute.

J. J. DAVIS, Lafayette, Ind. Term expires 1936.
W. C. O'KANE, Durham, N. H. Term expires 1938.
C. H. RICHARDSON, Ames, Iowa. Term expires 1937.

Representatives on Council of Union of American Biological Societies.

F. C. BISHOPP, Washington, D. C.
C. R. CROSBY, Ithaca, N. Y.

Representative on Board of Trustees of Tropical Plant Research Foundation.—HERBERT OSBORN, Columbus, Ohio.

Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints—B. A. PORTER, Washington, D. C., *Chairman.* Term expires 1937.

J. S. HOUSER, Wooster, Ohio. Term expires 1937.
G. M. LIST, Fort Collins, Colo. Term expires 1936.
P. J. PARROTT, Geneva, N. Y. Term expires 1938.
W. A. ROSS, Vineland Station, Ont., Canada. Term expires 1938.
W. J. SCHOENE, Blacksburg, Va. Term expires 1936.

Committee on Insecticide Terminology—C. M. SMITH, Washington, D. C., *Chairman.* Term expires 1940.

M. D. FARRAR, Urbana, Ill. Term expires 1937.
G. L. HOCKENYOS, Springfield, Ill. Term expires 1936.
WILLIAM MOORE, New York, N. Y. Term expires 1939.
R. H. ROBINSON, Corvallis, Ore. Term expires 1938.

Committee on Advancement of Official Entomology.—E. F. PHILIPS, Ithaca, N. Y., *Chairman.* Term expires 1938.

W. P. FLINT, Urbana, Ill. Term expires 1936.
T. J. HEADLEE, New Brunswick, N. J. Term expires 1937.

Committee on Popular Entomological Education.—J. A. HYSLOP, Washington, D. C., *Chairman.* Term expires 1938.

J. J. DAVIS, Lafayette, Ind. Term expires 1936.
E. O. ESSIG, Berkeley, Calif. Term expires 1937.

Journal of Economic Entomology Staff.

T. H. FRISON, Urbana, Ill., *Editor.*
H. B. WEISS, Trenton, N. J., *Associate Editor.*
ERNEST N. CORY, College Park, Md., *Business Manager.*
E. P. FELT, Stamford, Conn., *Honorary Editor.*

LIST OF MEMBERS

Active Members

Aamodt, T. L., University Farm, St. Paul, Minn.
Abbott, W. S., Silver Spring, Md.
Ackerman, A. J., 6 W. Sycamore St., Vincennes, Ind.**
Adair, H. S., Adair's Insect Control Service, Montgomery, Ala.
Adams, J. Alfred, State College, Ames, Iowa
Ainslie, C. N., 5009 Orleans Ave., Sioux City, Iowa
Alden, C. H., State Board Ent., Cornelia, Ga.
Alexander. Chas. P., M. S. C., Amherst, Mass.
Allen, H. W., Box H, Moorestown, N. J.
Allen, Norman, Experiment Station, Baton Rouge, La.
Allen, Paul B , Jr., 1026 N. 7th St., Allentown, Pa.

** Members who attended 1935 meeting.

Allen, R. H., Bd. of Agr., Boston, Mass.
Allen, Thos. C., Dept. of Ent., Univ. of Wisconsin, Madison, Wis.
Anderson, Edwin J., Penn. State College, State College, Pa.
Anderson, L. D., Truck Exp. Sta., Norfolk, Va.**
Anderson, O. G., Louisville, Ky. Tobacco By-Prod. Chem. Corp.**
Anderson, William E., Baton Rouge, La.
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